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Editorial.

Humus in Tropical Agriculture.

FOR some time the Department of Agriculture has been emphasizing the importance of humus in successful tropical agriculture. Its importance cannot be overstated and it may even be held that success in growing crops in the Tropics depends entirely upon *Humus*. The work which the Department has been attempting in connection with soil conservation in recent years and the establishment of low-growing cover crops is directed towards the preservation of losses by erosion and to the building up of soils which have already been washed.

Example after example can be found in Ceylon of washed out soils and of the consequent reduction in crops. In many instances, yields are being maintained and even increased by liberal manuring, but these results cannot be expected to continue unless careful attention is given to the organic matter in the soils.

Constant ploughing or harrowing of coconut areas without manuring seems to have resulted almost invariably in ultimate reductions in crops and it is now felt that too frequent cultivations are not desirable as it leads to a reduction in the humus content of the soils. It would be far preferable to grow low-growing

cover crops and to plough these in when they commence to flower, and the experiments now being started on some estates with Vigna (*Dolichos Hosei*) should be watched with interest.

The trials of *Indigofera endecaphylla* in the tea plots of the Experiment Station, Peradeniya, are also being watched by the planting community with interest, as also are several other trials now being made upon estates in various parts of the country.

The attention of readers is therefore directed to the papers in the present number which have an important bearing on this question. The paper on Green Manure which was read before the Dickoya Planters' Association by Mr. W. S. Burnett emphasizes the importance of humus in successful tea cultivations and discusses the various measures which can be adopted for its satisfactory maintenance, and the other papers dealing with soil bacteria in relation to cultivation and manuring and with the conservation of humus in Indian soils are worthy of careful attention.

The food requirements of the majority of soil bacteria are organic matter and lime and it is emphasized that the organic matter requirements of bacteria are very large. The value of organic matter as a means of retaining in the surface soil a sufficiency of moisture for the needs of the crop and the value of organic nitrogen as being credited to be more advantageous than inorganic nitrogen is discussed. The preference given by agriculturists all over the world for organic nitrogen is well known and it is yet somewhat difficult to explain for experimental data so far available in temperate countries are in favour of the inorganic sources of nitrogen. The question has been raised, however, whether the carbon dioxide given off in the decomposition of the organic matter is of any value to the plant and experimental tests are now in hand in England and Germany. Tests on this point should also be carried out under tropical conditions.

Very considerable advances are being made annually in our knowledge of soils and of the reactions which certain types of soils have on plant growth. The importance of organic matter in the soil and of humus cannot be over emphasized, especially by those intent upon maximum crop production. Unless adequate care is taken towards the conservation of organic matter in the soils reductions of crops must eventually take place. The importance therefore of green manures and of organic manures should not be overlooked.

Original Articles.

Contributions from the Ceylon Rubber Research Scheme.

Notes on Brown Bast and its Treatment.

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Organizing Secretary, Ceylon Rubber Research Scheme.

AT the Agricultural Conference held at Peardeniya in March, 1927, a paper was read on "Brown Bast and its Treatment" and this paper was published in the April number of the *Tropical Agriculturist*, 1927.

Many estates have taken a more serious interest in this subject and have commenced operations on the lines laid down in that paper. The writer has had further opportunities of observing the work being done and the results obtained and is now in a position to state that with reasonable care in treatment and close supervision the methods advised are certain to prove satisfactory; in fact, the results so far obtained have been more satisfactory than he had reason to anticipate. At the outset it was feared that the training of coolies to do such delicate work would present insuperable difficulties, but this fear has proved to be unfounded. Both in the diagnosis of the disease and in the treatment coolies have shown remarkable facility and there appears to be no reason why any estate that cares to seriously take up the work should not be able to train the requisite number of coolies to carry out successfully the work that is required.

One of the most frequent questions asked is " How long will it be before the tree can be re-tapped ? " The answer to such a question could not be given until some time had elapsed, and a tentative estimate of 4 years was suggested. The writer has since observed cases where tapping has been resumed on the treated surfaces after 13 months and in which an excellent flow of latex was being obtained. It is considered, however, that a longer period should be allowed to ensure a bark thickness suitable for an average tapper. It has been noted however that the texture of the renewed bark was such that tapping was relatively

easier than on ordinary bark. It is not presumed that so short a period will suffice always to allow a treated surface to be tapped but there are definite indications that the period during which the tree must be rested is not likely to be as long as was first anticipated.

With regard to the question of recurrence of Brown Bast after treatment some time must elapse before any reliable statement can be made. The writer is of the opinion however that certain cases of recurrence which have been reported to him could be accounted for as due to incomplete treatment. There is a strong tendency to cease scraping before the full depth is reached and a recurrence in such cases is inevitable. It is necessary, therefore, that careful supervision should be exercised and that no case should be allowed to pass as completed until it is reasonably certain that the outer limits have been reached and that scraping to the right depth has been carried out.

Members of the Rubber Research Scheme are urged to give the matter of Brown Bast and its treatment the most serious consideration for it has now been demonstrated that the practical difficulties are not so great as was anticipated and it is confidently believed that the results will fully justify whatever expense and trouble is incurred.

Report on "Revertex."

"REVERTEX" is the registered trade mark of a white paste prepared by concentrating latex to which has been added a preservative and an alkaline protective colloid. It is stated to contain between 20 and 30 per cent. of moisture. Samples examined at the Imperial Institute have been found to contain from 18 to 20 per cent. of moisture.

A number of uses have been suggested for Revertex, the most novel and generally applicable being for the preparation of mixings ready for calendering and extruding. For this purpose the Revertex is fed into a dough mixer and the screened compounding ingredients are added and mixed. It is stated that this operation is carried out quickly and that little power is consumed. The mixed paste is next rapidly dried on grooved rolls, which have been previously tightened and heated to between 120°C and 140°C. Compounds which cause coagulation or for other reasons cannot be added in the dough mixer may be added at this stage of the process.

When the percentage of moisture in the mixed rubber has been reduced to less than 1 per cent. the mixing is transferred to plasticising rolls and milled until sufficiently plastic. Sulphur is then mixed in and the material is ready for calendering.

It is claimed that the important advantages of using Revertex in place of crepe or sheet are:—

1. Economy in time and power in incorporating fillers, especially in the case of highly compounded mixings.
2. Economy in accelerator costs. It is stated that the effect of the natural accelerator is increased by the alkaline reaction of the Revertex.
3. Improvement in quality, especially higher breaking load.

A few trials of the process have been made on a small scale at the Imperial Institute and it is proposed to consider each of these claims in turn from the point of view of the results of these experiments.

1. Power Consumption.

In the preparation of mixings from Revertex ready for the calender it is necessary to use three different types of machine as compared with one in the preparation of mixings from plantation rubber. The three machines suggested for use in the preparation of Revertex mixings are:—

(1) A Werner-Pfleiderer dough mixer.

(2) Grooved stem-heated drying rolls.

(3) Rolls for plasticising the dry material and mixing in the sulphur.

It is stated that the output per unit of time and power consumption from these machines using Revertex is greater than that obtained from an ordinary mixing mill using dry rubber.

It is to be expected that the saving in power and time claimed for Revertex would be greater with highly compounded mixings than with mixings containing a high percentage of rubber. The experiments at the Imperial Institute were therefore carried out with three types of mixings, viz:—one containing rubber and sulphur only (90:10); one containing rubber, sulphur and a small proportion of zinc oxide (90:5:5); and one containing rubber, sulphur and a high proportion of zinc oxide (90:5:90).

The Revertex paste was found to be difficult to handle cleanly and quantitatively, and it compares very unfavourably with plantation rubber in this respect.

The zinc oxide, made into a paste with water, could be mixed into the Revertex merely by stirring (a Werner-Pfleiderer mixer not being available). There is little doubt therefore that the power costs for this operation should be very small when carried out on a commercial scale.

The mixing was next transferred to tightly-shut, grooved, laboratory washing rolls heated to between 125°C and 135°C. The paste required five to ten minutes to convert it into a dry plastic solid. It was not possible to measure the power consumed during this operation, but as the rolls were tightly shut it was probably appreciable. Even smooth milling rolls when tightly shut are found to consume a considerable amount of power.

Each mixing, as soon as prepared, was plasticised on laboratory mixing rolls and the sulphur then mixed in.

In the case of the rubber-sulphur mixing the Revertex was plasticised until the amount of power consumed was the same as that standardised at the Imperial Institute for the mastication of crepe and sheet. The Revertex at the end of this treatment was somewhat more plastic (14:18) than an average sample of masticated plantation rubber as determined by the rate of extrusion.

In the case of the mixing containing a large quantity of zinc oxide the dry Revertex mixing was plasticised as quickly as possible. For comparison, a composite sample of plantation rubber was masticated and mixed as quickly as possible. In both cases, the conditions as regards quantities of material, temperature of rolls and space between the rolls were the same. The Revertex took 24 minutes to plasticise and the plantation rubber 30 minutes to masticate and mix to approximately the same plasticity as determined by the rate of extrusion. The total amount of power consumed in plasticising the Revertex was 665 watt hours and in masticating and mixing the plantation rubber 1025 watt hours. These figures however include the energy consumed by the machine. In working on a commercial scale a different ratio would undoubtedly be obtained.

It seems clear that for a mixing containing a large quantity of zinc oxide less power is required to plasticise Revertex than is required to masticate and mix plantation rubber. The mastication and mixing of plantation rubber represents however the whole of the power costs but in the case of Revertex, mixing and drying costs have to be added. No satisfactory estimate of these costs can be based on the results of the present experiments.

A further point in connection with the use of Revertex is that a number of largely-used compounding ingredients, including compounds of calcium and magnesium, reclaim, etc., cannot be mixed with the paste and must be added either during the dry or the plasticising process. This factor adds to the difficulty of framing any estimate of the relative costs of treating Revertex and plantation rubber.

It was found that Revertex mixings easily "scorched" after addition of the sulphur, and for this reason it was not possible to extrude them at 90°C. The following values of D30 given by the parallel plate plastimeter show how quickly the Revertex-sulphur mixing hardens on keeping at 100°C.

Time of heating at 100°C.	D30*
mins.	mm./100
20	109
30	138
35	140
63	158
90	168

The results show that the longer the rubber is kept at this temperature the harder it becomes.

* D30 = Thickness (in hundredths of a millimetre) of sphere 0·4 grams in weight after pressing in parallel plate plastimeter at 100°C for 30 minutes.

2. Accelerator Costs.

The Revertex-sulphur mixing was found to vulcanise more than ten times as quickly as the corresponding sheet or crepe mixing. In the presence of zinc oxide the Revertex vulcanised nearly as quickly as the corresponding sheet or crepe mixings containing 1 per cent of diphenyl-guanidine. It is obvious therefore that the use of Revertex in place of crepe or sheet involves a saving in accelerators in those mixings where they are now used. In the case of an accelerator costing 3*s* per lb. and used in the proportion of 1 lb. per 100 lb. of rubber, the saving would amount to $\frac{1}{3}d$. per lb. of rubber used.

3. Quality of Vulcanised Revertex

(a) Tensile Strength and Elongation.

Rubber-sulphur mixing.—The results of vulcanisation and mechanical tests of Revertex in a rubber-sulphur mixing are as follows:—

	Time of Vulcanisation	Tensile Strength	Elongation		Slope
			At Break	At load of 1·04 kgs./sq. mm.	
	(mins.)	(lb./sq. in.)	(per cent.)	(per cent.)	
Sample 1	10	2300	893	805	39
do	15	2280	855	776	34
do	20	2250	814	731	32
Sample 2	10	1390	791	800	36
do	15	2240	795	712	36
do	20	1910	715	640	38

Plantation crepe and sheet have been found to have a maximum tensile strength in the mixing of approximately 2,400 lb. sq. in. which is developed at an elongation of about 775 per cent. under a load of 1·04 kgs./sq. mm. It will be seen therefore that as regards maximum tensile strength in a rubber-sulphur mixing the Revertex is not greatly different from plantation rubber. It is of interest to note that the two samples of Revertex were obtained at different times and that they behave similarly as regards optimum tensile strength and rate of vulcanisation. They differ however as regards maintenance of tensile strength over a range of cures and in the extent to which the elongation is reduced by increasing the time of vulcanisation from 10 to 20 minutes.

Zinc oxide mixing (90:5:5).—The results of vulcanisation

and mechanical tests in this mixing are as follows:—

Time of Vulcanisation	Tensile Strength	Elongation At Break	Elongation At load of 1·04 kgs./sq. mm	Slope
(mins.)	(lb./sq. in.)	(per cent.)	(per cent.)	
25	2440	795	694	33
35	2460	778	680	32
45	2480	779	678	33

An extended series of tests with the same mixing containing plantation rubber is not available for comparison. Isolated tests do not indicate that plantation rubber would be weaker than Revertex. If a comparison is made however with plantation rubber containing diphenylguanidine (90:5:5:1) the plantation rubber is definitely superior in tensile strength. The average results given by a large number of samples of plantation rubber in the diphenylguanidine mixing are:—

Time of Vulcanisation	Tensile Strength	Elongation At Break	Elongation At load of 1·04 kgs/sq. mm.	Slope
(mins.)	(lb./sq. in.)	(per cent.)	(per cent.)	
25	2,950	—	576	31·7

It would appear from the elongation results that 1 part of diphenylguanidine added to 90 parts of rubber has a more active effect than the accelerators in Revertex and it is therefore to be expected that plantation rubber containing this proportion of diphenylguanidine will be stronger than Revertex. On the other hand the Revertex-zinc-oxide mixing is not definitely stronger than the corresponding plantation rubber mixing without diphenylguanidine.

It will be noted that this Revertex mixing can be vulcanised from 25 to 45 minutes without much alteration in properties. This is an important point in favour of Revertex. A similar "plateau" effect is induced however by a number of accelerators.

Zinc oxide mixing (90:5:90).—The following are the results of the tests in this mixing:—

Time of Vulcanisation	Tensile Strength	Elongation At Break	Elongation At load of 1·04 kgs./sq. mm.	Slope
(mins.)	(lb./sq. in.)	(per cent.)	(per cent.)	
25	2690	736	573	41
35	2780	717	549	41
45	2660	700	556	41

These results can be compared with the average of those obtained with 90 samples of plantation rubber in the same mixing containing in addition 1 part of hexamethylenetetramine.

Time of Vulcanisation	Tensile Strength	Elongation		Slope
		At Break	At load of 1·04 kgs./sq. mm.	
(mins.)	(lb./sq. in.)	(per cent.)	(per cent.)	
38	2,690	—	480	—

It will be seen that the Revertex mixing in this case is slightly stronger than the plantation rubber mixing and that the elongation is a little greater.

The results of the tests with both zinc oxide mixings indicate that the tensile strength of Revertex mixings containing zinc oxide is not definitely superior and is sometimes definitely inferior to that of the corresponding plantation rubber mixings which contain in addition a suitable organic accelerator. This is particularly the case when the amount of zinc oxide present is small.

(b) Ageing Properties.

A Revertex-sulphur mixing was vulcanised for 8 minutes at 148°C and artificially aged in the oven at 70°C.

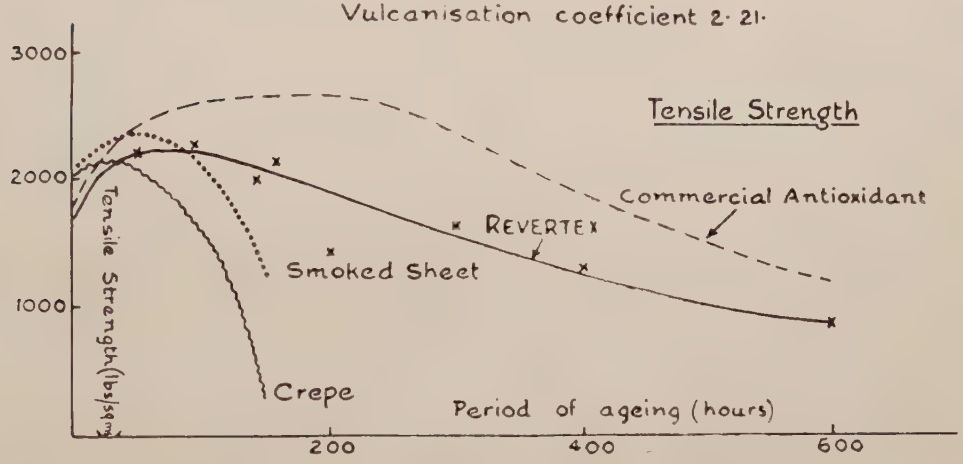
The following table and diagram show the results obtained in comparison with those given by plantation rubber.

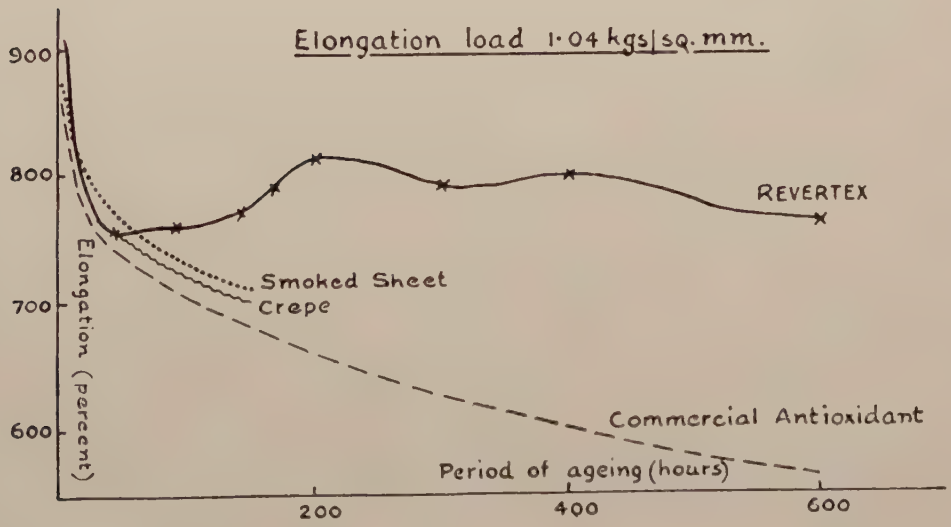
	Time of Vulcanisation	Period of ageing	Tensile Strength	Elongation at load of 1·04 kgs./sq mm.
	(mins.)	(hrs.)	(lb./sq. in.)	(per cent.)
Revertex	8	0	1590	916
		48	2230	751
		96	2260	765
		144	1990	770
		170	2170	791
		200	1440	815
		300	1460	790
		400	1300	800
		600	850	-
Crepe		0	2080	863
		48	2020	763
		96	1620	727
		144	390	700
Smoked sheet		0	2020	870
		48	2320	771
		96	2060	731
		144	1350	708

REVERTEX AGEING TESTS

Revertex sulphur mixing 90:10 vulcanised 8 mins at 14·8°C

Vulcanisation coefficient 2·21·





The Revertex was somewhat less vulcanised than the other forms of rubber as judged by the extent to which the rubber stretched under a definite load. The Revertex sample however displays such remarkable properties on ageing that there is no doubt that in this mixing (with sulphur only) it is definitely superior to plantation rubber in this respect, for not only does it maintain a good tensile strength for a long period of time, but it also maintains a good elongation.

It is concluded that on account of its good ageing properties products made from Revertex may compare very favourably in quality with those made from plantation rubber. If the properties soon after vulcanisation are compared however the advantage is with plantation rubber, particularly if used in conjunction with an organic accelerator.

Summary.

The following is a summary of the conclusions drawn from the laboratory tests at the Institute regarding the advantages claimed for Revertex.

(1) **Economy in time and power in incorporating fillers.**—Revertex is difficult to handle quantitatively. To convert it into dry rubber ready for calendering or extruding it has to be treated on three machines instead of one for plantation rubber. The experiments which it has been possible to carry out do not enable a definite conclusion to be drawn as to the relative cost of working Revertex and plantation rubber on a commercial scale. As soon as sulphur was added to Revertex mixings they very easily "scorched."

(2) **Economy in accelerator costs.**—In the case of accelerated mixings, it is not likely that this saving would be much more than $\frac{1}{3}d.$ per lb. of dry rubber.

(3) **Improvement in quality and higher breaking load.**—No superiority in tensile strength was observed when Revertex mixings were compared with the corresponding dry rubber mixings containing a suitable organic accelerator. The ageing properties of a Revertex sulphur mixing were much superior to those of plantation rubber without the addition of an antioxidant.

The precise advantages and disadvantages of Revertex are dependent upon the mixing used and the processes through which the mixed dry material is put.

Imperial Institute.

18th November, 1927.

Green Manure.*

W. S. BURNETT,
Wanaraja Estate, Dickoya.

ONE of the greatest problems the agriculturist has to face all over the world, has to deal with the replenishment of organic matter in his soil, which is so subject to yearly losses. In the tropics these losses occur more rapidly than in temperate climates and the maintenance of the organic matter in the soil under tropical conditions is consequently more difficult.

We in Dickoya are not alone in the problem we have to face, and the factors chiefly involved are leaching and soil erosion. The lay of the land, clean weeding and tropical downpours are chiefly responsible for the latter.

In America, where perhaps conditions are not so unfavourable as those we have to contend with, it is estimated that 4,000,000 acres have already been ruined by soil erosion and 8,000,000 acres greatly damaged.

As the wheat belt moved slowly on, it left in its wake hundreds of thousands of acres of derelict farms, which shows how unsuccessfully the problem was handled there, while it also reflects on their farming methods.

Standing as we do in the gateway to Up-Country tea (Hatton) one may well wonder whether something similar is not occurring in Ceylon. We are surrounded by Estates, which, if one cannot call them derelict or abandoned, are in anything but a flourishing condition, and from an agricultural point of view, one can only regard them as monuments to the lack of prevision on the part of our predecessors and excellent illustrations of the penalties which have been exacted for ignorance or neglect.

With our attention fixed on these, the question I would ask you to-day is, " Are we as a body ensuring that our inevitable yearly losses are being replaced ? "

I would ask you to ponder over this. To my mind the answer is an emphatic negative.

The importance of organic matter cannot be over-stressed. When decomposed it forms humus on which the micro-organic

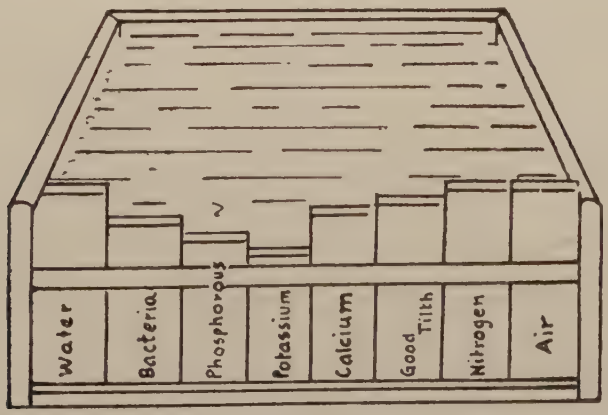
* Read at a meeting of the Dickoya Planters' Association, held at Adam's Peak Hotel, Hatton, on Monday, 28th November, 1927.

life of the soil depends, and on which we in our turn depend for the full benefit of our artificials. Without it the soil becomes sterile and micro-organic life is stilled.

Authorities all recognise the deficiency of humus in Ceylon soils and such being the case, let us see what this deficiency implies.

An American writer very clearly illustrates his argument by comparing soil to a concrete water tank, one side of which is composed of wooden staves:—

> " The capacity of the tank for holding water represents " fertility or the power of the soil for producing a good or " high yield. The staves which determine the water-hold- " ing capacity of the tank represent the positive factors " which determine soil fertility. The tank being free from " any leaks represents the negative factor viz:—the absence " of harmful agents."
>
> " If all the staves were as high as the concrete sides of " the tank, the tank would then hold its greatest amount " of water. If all the fertility factors were most favour- " able, the soil would have power for producing maximum " yields."
>
> " Just as the water-holding capacity of the tank may " be limited by the shortest stave, so fertility or the produc- " tive power of a soil may be limited or brought to naught " by one deficient element or an unfavourable soil condition. " Thus it is possible for a soil to lose its fertility or produc- " tive power through the depletion or loss of a single " fertilizing element."



He labels his staves, Water, Bacteria, Phosphorus, Potassium, Calcium, good Tilth, Nitrogen, Air, and of these let it be noted, Water, Bacteria, good Tilth, Nitrogen and Air, are wholly dependent or partly dependent on the supplies of humus in the

soil. This then is the limiting factor so far as we are concerned and to ignore the needs of the soil in this respect, while we pour in millions of rupees in the form of artificial fertilisers, is poor agriculture. It is not only poor but extravagant and wasteful.

It is extravagant because one is paying Rs. 100 to 150 per ton for organic manures containing 4% to 6% nitrogen. Rs. 170 to Rs. 250 per ton for inorganic manures containing 15% to 20% nitrogen, when this requirement can be obtained by other methods, at little or no cost at all.

It is wasteful as one is not catering for the micro-organic needs of the soil, the agents which break down and make available as plant food, the expensive mixtures we apply.

Nitrogen is one of the main requirements and moreover the most expensive. It is readily leached out unless abundant supplies of humus are available to retain it.

Having thus briefly indicated the crying need of our soils and the importance to be attached thereto, let us turn to methods of replenishment, and to that form of adding organic matter which is known as green manuring and which is the subject matter of this paper.

This consists of ploughing in or burying organic matter obtained from plants, the favourite ones being those we term "leguminous," and which the text books describe as plants which have the power of taking and fixing free nitrogen from the air.

From our agricultural point of view and for purposes of discrimination we might classify these under headings of "high shade," "low shade" and "ground cover."

As regards the former. When I first came to the District I was impressed with the very limited types available or subject to common knowledge. To an outsider, they appeared to consist of Acacias, condemned by our scientists as tending to spread a leaf disease of tea, Albizzias, a very moribund proposition, and dadaps.

Without disparaging the magnificent mixed cover possessed by individual estates, Dickoya in the main appeared rather dependent for its supply of organic matter on a few diseased and rather miserable Albizzias.

Failing anything better, and at the moment I want nothing better, I decided upon concentrating work on dadaps.

Surely these three leguminous trees are not the only shade trees we can draw on, and if you agree with me that Albizzias are doomed, or at any rate that their chance of survival is a poor one,

we are then reduced to the dadap as the only high shade we have to rely on, a state of affairs, I fancy you will agree, which is extremely unsatisfactory.

One occasionally comes across sporadic outbreaks of energy where other trees have been experimented with.

Acrocarpus fraxinifolias is noticed on the road to Dimbula and near Warleigh church. It is ornamental, as it has handsome foliage, while I believe its timber is of a slight value, but on the whole it is in my opinion unsuitable.

One tree however does impress me and that is *Dalbergia Assamica* which is well worth a trial, although it is a little difficult to establish.

In any case I think various types should be introduced and experimented with.

Of low shade, many and various types have been tried; the commoner and more popular ones being Boga medaloa and the Crotolarias, while *Tephrosia Vogelii* also grows sturdily in Dickoya.

Though excellent for young rubber, with tea they are inclined to bush out over the plucking surface and interfere with plucking, while loss of crop is brought about by run-up branches or excessive shade.

I would not however lightly dismiss them, as they undoubtedly can be made to serve and to be of immense value in soil management and improvement, if controlled and persisted in. The point to remember about them is that their removal is advisable before excessive woody developmnt of their stem or root system sets in.

We now are free to deal with ground covers which have lately been engaging attention and of these *Vigna*, *Indigofera* and *Desmodium*, are perhaps the best known.

My own experience with the two former has been, that although they undoubtedly have a smothering effect on weeds and prevent wash, their chief drawbacks are that they admit grass, which is toxic to tea and although control can be exercised over them fairly easily, neither being really vicious climbers, they are inclined to climb the tea as well.

They moreover encourage *Drymaria*, and clean weeding is very impractical under such conditions.

Two interesting questions now naturally arise. Is clean weeding such a vital necessity, and are not the drawbacks referred to more than compensated for by the prevention of erosion? Can we condemn in tea two creepers which are proving of such value in rubber ? Surely for some estates anything is better than the terrible scouring they are continually being subjected to?

Of *Desmodium triflorum*, perhaps the less said the better. Its matted root growth appears to affect tea detrimentally, soil aeration is prevented, and I believe its use has been practically discontinued.

We are thus, for the time being at any rate, apparently confined to high shade, and although with age it becomes unwieldy and cumbersome, its more vigorous roots open fresh avenues to exploring tea roots, and one has good reason to believe that shade is beneficial to tea.

The disadvantage mentioned can be overcome by periodical uprootings and fresh interplantings before the tree becomes unmanageable.

A matter in connection with leguminous plants, to which more attention might well be paid, is the question of soil inoculation.

We hear a lot on all sides that such and such a plant will not grow, but are our methods helpful and is not carelessness more often than not displayed? Many of us have seen short lengths of dadap cuttings stuck into the ground and this certainly does not lead to success.

The establishment of these plants is part of one's job and one must remember that, however unkindly, failure to do so may be looked on by one's employer as a tacit admission of one's failure as an agriculturist.

As far as soil inoculation is concerned no steps appear to be taken, but I would point out that much important work has been done with this at Home, and success is now being secured with certain bacterial cultures.

This however is not the popular method, the common ones employed being, as in the case of seed, by what is termed "Seed agglutination," that is to say by mixing seed, glue, and infected soil together, so that soil with the particular bacteria required adheres to the seed when dry, or else by soil transference, which is sowing soil of known infection over the areas where the farmer desires to establish his crop of legumes.

In this connection an excellent way to plant dadaps (in preference to cuttings) is from nursery grown stumps. Not only has the plant the advantage of a developed root system, but it also possesses the added advantage of conveying its own bacteria by means of the nodules on its roots. Nurseries are easily established on practically any soil, and a little cattle manure will give the incentive to the development of the bacteria.

The only drawback to this method that I have experienced or can conceive, is that whereas a cutting will grow true to type, a fairly large percentage of seedlings are thorny. I am afraid the

dadap possessed a thorny ancestry and that the laws of Mendel are now operative, but seed is cheap and if nurseries are carefully thinned, a sufficiently thornless type can be reserved and misgivings need not be held on this account.

Success with them is assured especially if hill tops are planted thickly, so that as the plants develop they will afford each other mutual protection from wind.

Perseverence is another asset and as the tilth improves and the soil becomes pregnant with life, every subsequent planting should spell a greater success. I would illustrate this by instancing an estate I am acquainted with, where after a complete planting failure with dadaps, a few cuttings were ultimately established round some lines. There is now such a smother of dadaps and the soil is so conditioned, that loppings take root where they fall, and are a source of anxiety to the Superintendent and a nuisance to weeding contractors.

And now, Gentlemen, I have not only kept you all quite long enough but I have come to the end of my remarks. I will close with an exhortation.

Mr. Renganathan on his retirement a short time ago, left a veiled farewell message—that we should look after our labour better—that it would pay us to do so.

That is true and it is equally true as regards the unseen workers in the soil. They are our tenants and with our labour constitute the life stream of the estate. But the difference is that their requirements are much simpler and that they pay rent if catered for.

They are in our soils now and no cash inducements are required in order to increase them. No Sarees for "Tee Vali," no rice @ 6/40 a bushel for them. Their only claim on you is housing in the shape of organic matter, and this we can offer them in the form of green manure.

Selected Articles.

Soil Bacteria in Relation to Cultivation and Manuring.

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THE object of this article is to point out the importance of bacteria as a definite factor in the cultivation and manuring of the tea bush.

The soil is usually considered as a mixture of particles of various sizes which are classified as coarse sand, fine sand, silt, fine silt, and clay, together with small amounts of organic matter and salts necessary for the growth of plants. This type of analysis gives the idea that the soil is a dead substance acting merely as a support and a reservoir of food for the roots of plants.

A brief examination of the facts shows that this view is incorrect. It is well known that plants can only take up from the soil substances in solution. Being soluble in water, these substances can all be washed out by rain, though in some cases, this leaching takes place very slowly. In any case it is obvious that unless some factor is constantly at work converting complex insoluble substances into simple soluble salts, all plants would sooner or later die of starvation.

A normal top soil contains bacteria and fungi in very large numbers, and these are quite indispensable for agriculture. Not only are they engaged in breaking down manures and dead matter, and in producing soluble phosphates from the soil particles, but certain groups take nitrogen from the air and leave it in the soil in a combined form, thus helping to preserve the fertility of the soil.

Types of Micro-Organisms in the Soil.—Three large groups of micro-organisms are found in the soil. These are called Fungi, Actinomycetes and Bacteria. The fungi, are mainly concerned with the destruction of wood, and their efficiency in this respect may be judged by the rate at which tea prunings disappear after hoeing in. These fungi must not be confused with those which produce diseases of the tea bush. The latter attack living tissues, frequently causing the death of the bush. The true soil fungi only attack matter which is already dead, and are unable to grow on living tissues except in rare cases.

With the actinomycetes or "ray fungi" we are not particularly concerned in this article. They are chiefly of interest because they are responsible for the "earthy" smell of soil, which is most marked after rain.

The bacteria carry out a much wider range of changes. Certain of them break down complex manures and the remains of dead plants and animals, converting the nitrogen to ammonia; others convert this ammonia to nitrate. Others take the nitrate out of the soil while engaged in breaking down green manures and jungle which has been hoed in. Another

group changes the soil nitrates and ammonia to free nitrogen which goes into the air and is lost;—the activities of these bacteria must be controlled. Nitrogen-fixing bacteria fix nitrogen from the air,—one of the most valuable processes known. Sulphur bacteria convert sulphur to sulphuric acid—hence the treatment sometimes advised, of adding sulphur to a soil to increase its acidity.

In short there are few processes connected with agricultural practice in which bacteria do not play an important part.

The Causes of Soil Deterioration.—The conditions in a normal jungle soil, before cultivation is commenced, are as follows. Bacteria in the soil produce nitrates, which are taken up almost completely by the heavy growth of plants and trees. From the trees, dead leaves and branches fall on the soil, adding large quantities of organic matter and nitrogen.

The organic matter is attacked by fungi and bacteria, the major portion being decomposed and given off into the air as carbon dioxide, which is again taken up by the green jungle. The nitrogen in the remainder is converted to nitrate by bacteria, and in this form once more enters the plant through the roots. The presence of organic matter in large quantities stimulates nitrogen fixation, and the soil steadily becomes richer, jungle growth increasing in proportion.

The increasing growth of jungle roots, however, has the effect of restricting bacterial activities, so that the amount of available nitrogen becomes progressively less. Eventually a point is reached at which the mineral food supplied, through the agency of the bacteria, is just sufficient to support the existing jungle, which in turn supplies little more organic matter than is necessary for the bacteria themselves.

Equilibrium having been established in this manner, there is the minimum of wastage, and soils in this state will remain for long periods without radical change in their composition, unless the cycle is upset, *e.g.*, by fire or floods.

The jungle is now cut down to form a tea garden. The trees and branches are removed and the smaller plants are buried or burnt. The soil is thus deprived of its normal source of organic matter. The land is hoed to destroy shallow rooted jungle and, the bacteria being now free to act without hindrance, decomposition sets in at a tremendous rate. Nitrates are formed much more rapidly than they can be absorbed by the tea and are washed out by rain. According to Mann, new tea gardens on very rich soil may give poor quality for some years, on account of the excessively coarse growth brought on by the accumulation of nitrates.

The amount of nitrogen lost in this way may reach alarming proportions as may be seen from the following figures (Mann):—

	Period under tea	Weight of nitrogen in virgin soil. lbs. per acre	Loss of nitrogen in lbs. per acre	Annual loss of nitrogen in lbs. per acre.
(1)	10 years	7,000	1,500	150
(2)	35-40 years	10,000	5,500	157
(3)	28 years	7,000	1,500	57·7
(4)	20 years	13,000	3,000	150

The amount of nitrogen removed in an eight-maund crop is about 30 lb. per annum and a little more is used in building the frame of the bush so that a total loss of up to 130 lb. per acre per annum may occur. During the early life of the garden this annual loss is probably very much higher, since the most readily available nitrogen is attacked first.

Much of the nitrogen in a soil is very resistant to bacterial attack, so that a soil which still contains 3,000 lb. of nitrogen per acre may grow very poor tea, while the addition of only 40 lb. per acre of a soluble form of nitrogen, *e.g.*, sulphate of ammonia or sodium nitrate, may bring about a 50 per cent. increase of crop.

In soil No. 2 above, for instance, the loss of 5,500 lb. out of 10,000 lb. per acre may represent almost complete exhaustion of the available nitrogen in the soil.

Cultivation also brings about a marked increase in the rate of decomposition of the soil's organic matter, and in a comparatively few years a rich soil may deteriorate considerably.

To preserve the fertility of the soil, the nitrogen and organic matter content must be maintained and this is best effected by making use of the soil bacteria.

The loss might be made good by the extensive use of artificial fertilisers alone, but the cost would be prohibitive. To take an example let us assume that the soil is losing annually 100-120 lb. of nitrogen per acre. To replace this with ammonium sulphate would require 5 cwt. per acre which, at the price of Rs. 180 per ton, would cost Rs. 45 per acre, plus freight.

This, however, would do nothing towards maintaining the content of organic matter, apart from stimulating the growth of jungle and bush. If oilcake were used to supply both nitrogen and organic matter the quantity required would be 28 maunds per acre at a cost of Rs. 105. Any attempt to preserve soil fertility by the sole use of artificial manures is thus economically unsound.

The Nature and Habit of Bacteria.—The importance of bacteria is nitrogen from the air and making it available for plants. An important group of these consists of well known legume bacteria, which are found in the nodules on the roots of green crops such as Boga medeloa, cowpeas, dhaincha, and the like. Others live a free life in the soil and obtain their food from fresh organic matter, fixing nitrogen in return.

The most successful agricultural practice thus resolves itself into making the greatest possible use of these bacteria, and it is hoped that this article will show how these, and other valuable organisms, may be best encouraged.

The Nature and Habits of Bacteria.—The importance of bacteria in the soil having been established, their nature and mode of life will be considered, together with the application of this knowledge to agricultural practice.

Although commonly referred to as "bugs", bacteria are in reality not animals but plants of a low order, being even lower down in the scale of life than the fungi. Like the fungi, they are devoid of the green colouring matter of plants and therefore they cannot use the energy of the sun's rays directly.

In point of fact, direct sunshine is nearly always fatal to bacteria, which probably accounts for the lower numbers of these organisms in the top inch or two of soil (see below).

Their inability to use the energy of the sun direct determines their mode of nutrition. They must obtain their energy second-hand, by breaking down substances with a high energy content, *i.e.*, residues of plants and animals.

For this reason the majority of bacteria fall naturally into two groups, according as they live on living or dead matter. The first group contains the bacteria which cause diseases of living animals and plants, and the second group those which reduce the dead material to simple bodies which can once more be absorbed by plants. It is the failure to distinguish between these two groups which has given rise to the idea that all bacteria are harmful and should be suppressed where possible. Actually, were all bacteria and fungi destroyed, life on the earth would become extinct.

The soil bacteria belong almost entirely to the second group, with the exception of a few species which live on mineral salts only.

Form of Bacteria.—Bacteria occur in a variety of shapes, the most common being rods of varying length, and small spheres. In addition there are "comma" and spiral shapes. They are usually found in "colonies" which may consist of a few hundred or many million bacteria. A colony of five million typical bacteria would occupy the space of a pin's head. In the soil, these colonies are usually found surrounding small particles of lime.

Although they are plants by nature, bacteria are able to move about in the soil water. By special staining methods they are seen to have long waving "arms" of flagella, and these are lashed violently backwards and forwards in the liquid, causing the organism to move at a considerable speed in relation to its size. These flagella are of special interest in connection with the bacteria of green crops.

Growth and Reproduction.—In bacteria the simplest and most efficient form of reproduction is met. When a cell has grown to its full size it divides in two, and each of the resulting cells is exactly the same as the parent. Sexual reproduction is absent and in consequence, cross-breeding being imposible, bacteria tend to maintain their characteristics. For example, there is little difference between the nitrifying organism of Assam and that of England.

Certain bacteria also form spores which are very resistant to heat and may be boiled in water without loss of vitality.

Under favourable conditions a single cell can form two cells in half an hour. At this stage, after two days the descendants of a single cell would number 281,500,000,000. Under ordinary conditions, lack of food soon slows down this rate of increase, though if food is available in large quantities the effects of bacterial growth may be marked.

This is brought out by the temporary depression of crop noticed when a green manure or paddy straw is hoed in. Enormous quantities of cellulose are put into the soil, and the cellulose bacteria increase rapidly. In so doing they remove almost the whole of the nitrates from the soil, and until the nitrogen in the green material starts to decompose, the tea suffers from nitrogen starvation. The same fact has been brought out in a laboratory experiment with oilcake. When this manure was added to soil at the rate of 8 tons per acre there was an immediate loss of 90 lb. nitrate per acre, probably the whole of which went to feed the cellulose bacteria. All the nitrogen removed is returned to the soil when the bacteria die off, after their work is done.

Bacteria in the Soil.—In the soil, the bacteria occur in incredible numbers, a normal fertile soil containing about 100,000,000 to the ounce, or approximately five thousand million per acre. These great numbers are somewhat discounted by size—the average bacterium measuring about one twenty-thousandth of an inch in length—but they are nevertheless sufficient to make all the difference between a naturally fertile soil and one on which tea culture is only possible by constant resort to artificial fertilisers.

Distribution of Bacteria in Soil.—The numbers vary greatly with depth. The following table shows the distribution in the top two feet of soil :—

Depth	Number of bacteria per ounce of soil.
2 inches	24,500,000
4 "	40,800,000
6 "	40,800,000
12 "	1,820,000
18 "	525,000
24 "	100,000

Here is the explanation of the well known infertility of the subsoil. The reasons for the failure of bacteria to survive in any but the top few inches are several. Lack of air in the subsoil is one of the main factors ; another is the almost complete lack of available organic matter. In addition, the soil itself behaves as a very efficient filter in preventing the bacteria from being washed down by rain acting in the same way as the earthenware candle in the filter which is to be found in every bungalow.

These figures act as a strong condemnation of the practice of digging drains and piling the excavated earth upon the tea on either side. If new drains are to be opened in an area already under tea, the subsoil should be spread thinly over the soil for some distance on either side. Whenever it becomes necessary to deal with subsoil in large quantities it should be freely mixed with cattle manure, which will have the effect of increasing the content of organic matter while supplying a very large number of bacteria.

The same applies when it is necessary for any reason to plant up land from which part of the top soil has been removed *e.g.*, by wash.

This infertility of the subsoil is one of the main arguments in favour of terracing on steep slopes in an exposed position. The top soil with its attendant bacteria and organic matter is easily lost and may take years to replace. On gardens where the top soil has already been lost, the continued use of artificial fertilisers such as sodium nitrate and ammonium sulphate is merely putting off the day of reckoning, and the health of the bushes will be maintained only while these manures are present. The counsel of perfection would be to build up a new top soil by heavy dressings of cattle manure, green crops, and decay-jungle.

The Conditions Necessary for Bacterial Life.

Air.—There are two groups of bacteria in the soil, one of which requires abundance of air for its life processes while the other can live in entire absence of oxygen. The members of the first group carry on most of the valuable processes in the soil, while those of the second group are on the whole undesirable. One species of the latter has the power of destroying nitrates and giving off free nitrogen causing a very serious loss to the soil. When the oxygen supply is insufficient these and other bacteria actually produce plant poisons so that their harmful effect on plants is twofold. It is thus necessary to restrict their activities as far as possible.

(a) by keeping the soil in good tilth and so allowing air to penetrate freely to the greatest possible depth.

(b) by preventing waterlogging of the soil by an adequate drainage system.

Moisture.—Bacterial activity is dependent on a sufficient supply of moisture in the soil. For the best working, the moisture content must lie between certain limits. Thus at Tocklai the optimum moisture content for the nitrifying bacteria is near 14 per cent. (*i.e.*, 35 per cent. of saturation). When the moisture content falls to 10 per cent. (25 per cent of saturation) in the cold weather, bacterial action is checked, and the bush is left without its normal food supply. Similarly when the moisture content rises to near the saturation point, the activities of bacteria are greatly restricted, and unless steps are taken to remove the excess water by drainage, a race of harmful bacteria may take possession of the soil. The disappearance of excess moisture from a well drained soil is brought out by the following figures :—

Date.	Rainfall	Percentage of moisture in soil.
May 27th	0·24"	18·41
" 28th	nil	17·27
" 29th	0·05"	——
" 30th	nil	16·30
31st	nil	14·40
June 1st	nil	13·89
" 2nd	1·72"	18·38

Thus under dry conditions the moisture content of the soil falls fairly rapidly until it reaches the optimum. From other figures it is found that below this point the soil holds on to its moisture with greater tenacity.

The actual degree of saturation most favourable to bacteria appears to vary in different soils, usually lying between 40 per cent. and 60 per cent. The following figures illustrate this point.

Degree of saturation.	Production of nitrates from peptone by bacteria (milligrams per 100 gms. of soil).		
	Tocklai.	Amluckie.	Red Bank.
35%	7·36	——	——
40%	6·05	7·14	8·52
45%	4·90	8·24	9·89
50%	4·39	8·79	16·48
55%	3·57	10·44	13·20
60%	——	12·36	7·70

To preserve the maximum fertility, the soil moisture must therefore be kept as near as possible to the optimum :—

(1) by adequate draining to remove excess water during the rains.

(2) by the use of the cold weather mulch to maintain the moisture content at the highest possible level during the cold weather.

Prolonged droughts such as occur fairly frequently in the tea districts of the Terai and South Sylhet may cause a serious destruction of soil bacteria, leading to a slow recovery of the bush. When possible it is as well to apply a dressing of cattle manure on weak sections after a severe drought, as this will have the double effect of supplying food for the bush while adding a large number of active bacteria to the soil. If the drought has not been too severe, the effect of the first rain is most marked. The nitrate content of the soil, which has remained at a very low level throughout the cold weather, suddenly jumps up to nine or ten parts per million. This sudden increase doubtless plays a considerable part in bringing on the first flush.

Food.—The food requirements of the majority of soil bacteria may be placed under two headings, *viz.* :—

Organic matter.

Lime.

Lime does not act so much as a true food, but rather as a neutraliser of the acids produced by the bacteria in their normal life. This will be discussed below.

Organic matter is used by bacteria in enormous quantities. For example, American workers have found that the nitrogen fixing bacteria when supplied with straw as their food fix 7¼ lb. of nitrogen from the air while decomposing a ton of straw. When the green matter from clover was supplied instead of straw, the amount of nitrogen fixed was about 27·5 lb. per ton of material decomposed. It is probable that the results with the green manures in use in the tea districts would be comparable with the latter figures, but work on this point has not yet been carried out.

From these figures it appears that the amount of nitrogen fixed by the soil after a green crop has been hoed in would be in the neighbourhood of 80 lb. per acre, apart from the 20 lb. fixed by the crop itself. It must be pointed out that these figures were obtained as a result of laboratory experiments and in the field different results might be obtained. From a good crop a gain of at least 100 lb. nitrogen per acre is to be expected, which compares very favourably with the usual dressing of 30 lb. given as ammonium sulphate.

The organic matter requirements of bacteria are seen to be very large. Under jungle conditions, these requirements are supplied by the annual leaf fall from trees and by the succession of low-growing grasses. On the tea garden, however, jungle must be suppressed for it competes with the bush for food. The depression caused by jungle is well brought out by the following figures obtained from the Borbhetta cultivation plots.

Plot No.	Treatment	Relative efficiency of nitrifying bacteria	Crop 1926.
87	Monthly cheel	201·0	10·60
93	6 light hoes	176·7	10·16
88	1 light hoe. Extra manure	141·3	6·16
95	Sickled only	100·0	3·68

Plot 87 is kept free from jungle. 93 is nearly free while on 88 and 95 jungle is plentiful. It is interestng to note that the presence of jungle has had harmful effects on the soil bacteria as well as on the tea. This is possibly due to toxins given off by the jungle roots.

On the contrary, the practice of growing shade trees is very beneficial. The roots of the trees are too far below the surface to have much effect on the bacteria in the top few inches of soil. The wide-spread root system does much to minimise the loss of nitrates and soluble salts which would otherwise take place through leaching, and finally the tree itself deposits annually a large amount of organic matter, containing some 3 per cent. of nitrogen.

From the figures given above it is clear that the suppression of jungle is one of the most important factors in tea garden management. Undoubtedly the best method of effecting this is to grow tea bushes that touch each other so that jungle has no chance to grow—while the organic matter content of the soil is partially maintained by leaf fall and prunings. This is a counsel of perfection not easy to follow on gardens with a large percentage of deteriorated tea and vacancies, but approximated to on very large areas of good tea.

Jungle is usually eliminated by the use of the light hoe. Unfortunately the light hoe is very wasteful of the soil reserves for it is followed by a sudden increase in nitrate amounting to some 20 lb. per acre (on Tocklai soil). A heavy fall of rain following cultivation will remove almost the whole of this and the soil will be poorer in proportion. The destruction of organic matter is stimulated in a similar manner.

This loss after light hoeing is avoided to a considerable extent by substituting "cheeling" or cultivation with a spring-time harrow and buffalo, both of which effectively suppress jungle while disturbing the soil to a depth of a few inches only. The possibility of using either of these forms of cultivation depends largely on circumstances, labour being concerned in the former case, and the drainage scheme, transport facilities, and distribution of shade trees in the latter.

The fact remains that cultivation causes considerable losses of nitrogen. These can be made good in two ways, *viz.*—by addition of manures and by nitrogen fixation. Nitrogen fixation is, however, dependent on the amount of available organic matter. It is therefore clear that above all things the organic matter content of the soil must be kept up, if the bacterial population is to be kept in good working order. This fact is so important that a manuring scheme taking no consideration of the soil bacteria may be considered incomplete.

The tendency of late years has been to rely more and more on the purely artificial fertilisers such as Sulphate of ammonia and Calcium cyanamide for the nitrogen supply, chiefly on account of their low cost. It is important to remember that these manures are added solely with the idea of increasing the crop, and that they have little or no direct beneficial effect on the soil bacteria. A programme incorporating these manures must always include regular green cropping or dressings of cattle manure, preferably well rotted with paddy straw.

Lime.—For the majority of bacterial processes a neutral or slightly alkaline soil is required. Tea requires an acid soil and anything approaching neutrality appears to be definitely harmful. On the other hand, the fertility of the soil depends largely on the activities of the bacteria, to which lime is an essential. The difficulty is met by a compromise, lime being added in quantities insufficient to change the reaction of the soil, but under conditions where it will have most effect on the bacteria. To take an example, let us consider a typical tea soil with a "Hopkins acidity" of 400. This means that 400 lb. of lime would be required to bring 1,000,000 lb. of soil to a condition of neutrality. Taking the weight of an acre of soil to a depth of nine inches as 3,000,000 lb., we find that this soil would require 1,200 lb. lime per acre to make it neutral.

Now five maunds of crushed limestone contains about 200 lb. of free lime, so that this amount could be supplied per acre without making any appreciable difference to the acidity of the soil, although being of great value to the bacteria. The best time to add lime is before sowing a green crop, so benefiting the green crop itself and also the bacteria on whose presence and activity the efficiency of the crop depends. The lime should be distributed only in the rows where it is intended to sow the green crop, and preferably in the seed-bed itself.

Experiments conducted at Borbhetta showed that on this particular soil, Rahar would not grow at all without lime. When this deficiency was made good the crop obtained increased with increasing amounts of lime, until a dressing of 80 maunds of crushed limestone produced a Rahar crop of 250 maunds per acre.

The Tocklai lime policy thus becomes comprehensible when considered in terms of bacteriology. Continual applications of lime over a period of years, or the application of a large dressing is seldom, if ever, advised, but small dressings are recommended from time to time to satisfy bacterial requirements.

The conditions for optimum bacterial working may now be summarised :—

Aeration of the soil.

Ample moisture, but avoidance of excess by draining.

Plentiful supply of foodstuff in the form of organic matter.

Supression of jungle.

Small amount of lime at intervals on the more acid soils.

Green Manuring.—The space available will not allow of a description of all the bacterial processes taking place in the soil. As the practice of green manuring is of great importance in tea soils, the relation of bacteria to green manures will be dealt with more fully here, and a discussion of other bacterial processes will be left till later.

It is generally realised that bacteria are intimately connected with green manures. On the roots of all members of the legume family may be found small nodules. These vary in numbers with different species of plants, and with different conditions of growth.

If one of these nodules be cut in two, it is found to consist of an outer white layer of firm consistency, surrounding an inner mass, often pink in colour, which is soft and slimy. This inner mass is seen under the microscope to consist of enormous numbers of slender bacteria, entirely filling the cells of the nodule. It is to these bacteria that the legumes owe their value as green manures, for, as stated above, they have the power of taking nitrogen from air, building it into complex soluble substances, and passing these on to the plant. In return form these substances, the plant supplies the bacteria with sugars, water and salts—substances which enable the bacteria to carry out their work of nitrogen fixation.

There is here a perfect example of division of labour.

The necessity of bacteria for economical growth of green crops. The ordinary green plant takes up its nitrogen as nitrate or ammonia. On this account jungle competes with the tea bush for food, and as it has its roots mainly in the top few inches of soil, where bacterial action is at its highest, the jungle has first call on the food supply. Hence, apart from reasons of convenience, jungle must be suppressed.

A green crop without nodules acts in the same way as jungle, the rate of growth and final crop being determined by the amount of nitrate and ammonia in the soil. Consequently any growth of a green crop without root nodules is at the expense of the tea.

If nodules are present on the roots, the position is altered. The bacteria in the nodules draw relatively large quantities of nitrogen from the air, and with the aid of this nitrogen the plant grows far larger than it would were it living on soil nitrates alone. For successful green crops the requirements of the bacteria must be studied and met.

The bacteria are mainly present in the soil in an inactive state. They possess no power of moving through the soil and little power of infecting roots of legumes. When a soluble phosphate is supplied the bacteria develop flagella, become highly active and are able to infect the plants readily. The use of phosphate is therefore a wise policy wherever green crops are to be sown, and many cases of failure may be put down to the neglect of this precaution. The best phosphates to use are Basic slag,

Superphosphate, Belgian flour phosphate and Algerian phosphate. The quantities usually recommended are as follows :—

Superphosphate	2 mds. per acre.
Basic slag	2 " "
Belgian phosphate	3 " "
Algerian phosphate	2 " "

Inoculation of Green Manures.—From the above remarks it is clear that the value of a green manure depends on the extent of infection by bacteria. The question now arises, whether the legume bacteria in the soil are present in sufficient numbers to secure the maximum infection. In some districts it is found almost impossible to grow a good green crop and the idea suggests itself that lack of bacteria may be the cause. If this is so, artificial inoculation of the soil or the seed might be restored to with success. So far, little work has been done along these lines in the tea soils. A few isolated trials were made in the Tocklai district this year with varying results. The bacteria were grown on an agar (china-grass) jelly, and just before planting, the seed was moistened with a suspension of these bacteria in water.

Cowpeas gave poor results. Not only was it found difficult to grow the bacteria, but the inoculated plants were barely as good as the uninoculated. Boga medeloa was unsatisfactory owing to unfavourable climatic conditions and practically the whole crop failed. With dhaincha more promising results were obtained. The results of the experiments were :—

Yield from 11 rows uninoculated.	Yield from 11 rows inoculated.
590 lb.	918 lb.

Increase from inoculation 328 lb. = 55 · 6 per cent.

The seed was planted in alternate rows, alternate rows of seed being inoculated. Phosphate was not supplied and the soil in that section was poor. In almost every case, an inoculated row gave a greater weight of green material than the uninoculated rows on either side.

Definite conclusions cannot of course be drawn from a single experiment of this nature. This Department will be pleased to get into touch with any planter who has continual difficulty in establishing a green crop and who would like to carry out experiments in inoculations.

The science of agriculture has passed through three main stages in the course of its development. In ancient times the Mechanical stage held the field. Improvements were chiefly along the lines of cultivation and drainage, although a considerable amount was known about fallowing and the use of green manures such as clover in a crop rotation. At the beginning of the nineteenth century agriculture passed definitely into the Chemical stage and tremendous advances were made in the science of manuring; during the closing years of the same century the Biological era arose and gained favour in so rapid and sensational a fashion that there was a tendency in certain circles to regard bacteria as the beginning and end of agriculture.

Actually there are no hard distinctions to be drawn. The mechanical, chemical and biological phases are all intimately connected and interdependent; and a change which affects one will affect all.

In this article the claims of the bacteria have been put forward. Their importance in soil fertility has been brought out and the conditions they prefer have been enumerated. No attempt has been made to deal at length with individual bacterial processes in the soil, but the importance of organic matter has been emphasised, since this substance is the chief food, directly or indirectly, of the majority of soil bacteria; and on these, eventually, the economic cultivation of the tea bush depends.—*Quarterly Journal of the Scientific Department of the Indian Tea Association,* Part III, 1927.

The Conservation of Humus in Indian Soils.

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THE prime requirement of Indian arable soils is an adequate supply of organic matter or humus; this statement no doubt partakes of the nature of a truism, but the writer's object in making it is to draw attention not only to certain considerations arising in connection therewith, but to the fact that there appears to have been a dangerous tendency in the past towards failure to recognize its importance.

The functions of humus in cultivated soils are numerous and most of them are well known, although some are still obscure. In India one of the most important is the modification of the relation between soil texture and the supplies of air and water to the plant; a further one less fully understood has to do with the retention, in an accessible condition, of plant food for the crop. The effect of humus upon soil texture is not only its most important function but is one which cannot be performed by any other substitute; it is not too much to say that the fertility of a soil depends primarily upon its content of organic matter and that when agriculturists refer to a soil as being "in good heart" they mean that it contains sufficient humus to secure fertility.

To increase the natural fertility of Indian soils we are taught by the experts of the Agricultural Department that it is necessary to practise thorough cultivation, and that the old fashioned indigenous methods of the Indian cultivator must be improved upon by the use of more efficient implements such as those employed in Western countries. It is indeed easy to demonstrate in actual practice the increase in crop which can be obtained by this method, and as the capital outlay involved is small and the labour required is cheap, the recommendation to make use of increased tillage appears on the face of it a rational one. In 1919 the writer drew attention, in a paper* read before the Indian Science Congress in Bombay, to the danger attending the introduction into India of high yielding varieties of crops and of intensive cultivation methods; these were shown to lead inevitably to depletion of soil reserves in the absence of adequate provision for the maintenance of the latter. In the most recently published number of the *Review of Agricultural Operations in India*, 1925-26, by the Agricultural Adviser to the Government of India, this danger receives official recognition, both with regard to the effects of improved varieties of crops and intensive cultivation. The remedy recommended, however, is the use of organic manures on account of their favourable influence on the texture of the soil, and a warning is given against the employment of artificial manures which

*Agricultural Journal, India, XIV. p. 2.

have a tendency in the opposite direction. The object of this paper is to draw attention to the fact that although the use of organic manures has all the advantages claimed for it by the Agricultural Adviser to the Government of India, yet it is a mistaken policy merely to advocate the replacement of the depleted organic matter of the soil, without making any attempt to find out whether some less exhausting method of securing fertility than excessive cultivation cannot be adopted. This is especially the case where these organic manures are to be considered the principal scources of the necessary nitrogen supply.

It is no doubt necessary in India to make strenuous efforts to improve the primitive methods and implements of cultivation in general use, and this with one specified object amongst others, namely, the formation of a deeper layer of fertile soil in a condition of good tilth such as will conduce to the development of a deeper and more extensive root system. Improved cultivation of this type cannot do anything but good, but on the other hand there are mistaken methods of varying it in the direction of multiplication of ploughings which will inevitably lead eventually to disastrous results. Soil humus, far from being an imperishable substance, is rapidly attacked and destroyed by natural processes continually in operation. These processes are in part purely chemical and in part due to the activities of micro-organisms, but both of these classes of action are strongly activated by stirring the soil, which promotes aeration and therewith the numerous oxydizing processes, resulting partly in formation of carbon dioxide and partly of nitrates. The latter are removed from the soil either by rain-water or by the crop, the former, dissolved in the soil water, helps to bring into solution the mineral constituents necessary for plant growth. Mechanical stirring of the soil produces a further effect in the breaking-down of soil aggregates and particles and thus exposing fresh surfaces to oxydation and bacterial attack; this result is again increased by the mutual attrition of particles which removes from their surfaces the accumulated protective layer or deposit, resembling rust, resulting from the oxidative or micro-biological processes above-mentioned.

The obvious effect of this intensive cultivation is an improvement in the immediate yield of the crop due to the increase in availability of the plant food present in the soil; this however is obtained not only at the expense of the reserves of plant food in the soil as a whole, but more especially with reference to the destruction of its humus content. This use of the organic matter is a wasteful and unnecessary method of securing supplies of plant food, whether nitrogenous or phosphatic, for the reason that whereas no other soil constituent can fulfil the special physical functions of humus, it is perfectly easy to supply nitrogen, phosphates and potash, under controlled conditions and in quantities which experiment can determine as suitable in the form of fertilizers. The destruction of serious percentages of the total humus content of the soil in order to secure a few pounds per acre of available nitrogen represents a method as uneconomic and wasteful as that involved in the use of an improperly balanced ration for cattle, in which the presence of an undue proportion of albuminoids involves the utilization of this expensive tissue-forming constituent as a means of heat and energy, in place of securing the latter by the combustion of carbohydrates and fat. In the same way intensive cultivation involves the diversion of an unduly large proportion of the soil humus from its proper physical function to the alternative, or rather additional, role of a supplier of plant food.

It is perhaps well to point out here that humus has an importance in the soil as a possible provider of organic nutrient or possibly stimulant substances to the plant, but on this point our information at present is scanty and uncertain.

It is of course to be remembered that an important function of organic matter in the soil is to provide food and energy for certain useful micro-organisms such as the nitrogen-fixers; although cultivation by securing adequate aeration promotes this important action, yet excessive tillage by depleting the soil of its humus will eventualy reduce it to insignificant proportions. The loss of humus is accompanied by a corresponding loss of soil nitrogen; this result is drawn attention to by Russell.* "Directly ploughing and cultivation operations begin great losses of nitrogen set in"; and again "The conditions for this decomposition" (involving evolution of gaseous nitrogen) "appear to be copious aeration such as is produced by cultivation and the presence of large quantities of easily decomposable organic matter. Now these are precisely the conditions of intense farming in old countries and of pioneer farming in new lands and the result is that the reserves of soil and manurial nitrogen are everywhere being depleted at an appalling rate."

H. A. Tempany, Superintendent of Agriculture, Leeward Islands, draws attention in his note dealing with fertility of soils in the Tropics, published in the *"Transactions of the Third International Congress of Tropical Agriculture"* to the rate of decay of organic matter in the soil: "It was found that in periods varying between six and twelve months the content of organic matter become reduced by amounts ranging between 12 and 30 per cent. of the total originally present." This rapid loss of humus occurred both in the laboratory and in the field. Numerous experiments carried out in the writer's laboratory at Pusa showed conclusively, both by measurement of carbon dioxide formation and of loss of nitrogen, that this very high rate of decomposition of organic matter is to be expected at the relatively high temperatures of Indian soils, and that it is greatly accelerated by aeration and mechanical disturbance.

Consideration of the above facts leads to the conclusion that great caution is necessary in making use of intensive cultivation as a means of securing an increase in fertility in Indian soils. We are faced with a problem of great complexity, any successful solution of which must depend upon securing much more accurate information than we at present possess as to soil conditions in this country. In the writer's opinion information should be sought along the following lines amongst others:—

(1) Experiments should be carried out to determine the conditions making for excessive rates of destruction of humus in various types of soil.

(2) Experiments should be made to determine the possibility of conserving reserves of humus by reducing the intensity of cultivation and at the same time supplying appropriate quantities of available plant food in the form of fertilisers.

With regard to (2) it is of interest to note that, when discussing this subject recently with the Chief Scientific Officer of the Indian Tea Association, this gentleman informed the writer that the suggestion above made was in entire accord with the most up-to-date policy of tea cultivation in Assam, as it combined reduction of labour with conservation of humus.

Here may be noted an important principle underlying the proper use of fertilisers in India, namely, that artificials should not be used as substitutes for organic manures but in conjunction with the latter; this does not mean that they cannot be used alone on land which contains a sufficiency of organic matter, but that the cultivator must not take them as complete substitutes for the cowdung or oil-cake which he would ordinarily employ. On the other hand, it has already been proved that by judicious use of artificials in

*Russel, E. J. *Soil Conditions and Plant Growth,* 5th Ed., pp. 246-247.

conjunction with cowdung the available supply of the latter can be made to cover a much greater area with economic effect, this being made possible by the use of sulphate of ammonia as a substitute, not for the whole usual application of cow manure, but for a third or perhaps a half of the latter; in the experimental results which have recently come to the notice of the writer in India this partial substitution was followed by increases of crop of a substantial order and sufficient to give a highly satisfactory economic return. It is highly advisable, therefore, both in the interest of conservation of humus and of that of the extension of the area under treatment with cowdung or other organic manures, that extensive experiments dealing with the possibilities of this partial substitution method should be carried out. It is perhaps unnecessary to say that such experiments should include investigation of the use of all kinds of artificial fertilisers, as, although the most obvious economic returns have been obtained with nitrogenous artificials, it is highly probable that still better results would follow the use of more complete applications, which would include minerals as well.

The value of humus and its functions in the soil are too well known to need further discussion here, but it may be well to draw attention to a particular point in connection with its value as a means of retaining in the surface soil a sufficiency of moisture for the needs of the crop, at a time when arid conditions render such supply necessary. In irrigation tracts there is the danger that the existence of a controlled water supply, independent to some extent of climatic conditions, may lead to neglect of the conservation of the soil humus because of the less insistent necessity of observing this as a means of retaining soil moisture; in districts where cold weather crops are grown under arid conditions any such neglect leads to obvious failure; the land is then no longer, "in good heart" and can only be brought back into this condition by prolonged operations involving green-manuring, heavy applications of organic manures, or fallowing. As this particular function of humus although of the greatest importance is by no means its only one of value, there is a distinct danger in irrigation tracts of a lowering of soil fertility as a result of failure to keep up supplies of organic matter in the soil, this being a consequence of failure to note the falling off of crop returns which would inevitably follow any serious reduction of humus content under arid conditions. Thus we may expect to find excessive cultivation practised in an irrigation area as compared with the smaller number of ploughings made use of in other districts. This will in time be followed inevitably by depletion of the organic matter content of the soil and a lowering of fertility, and probably by a corresponding reduction in the effectiveness of irrigation. In this connection it may be well to bring to remembrance, Leather's findings at Pusa which demonstrated the reduction in the quantity of water required to produce unit weight of dry matter in the crop, as a result of provision of suitable supplies of available plant food in the soil. This affords a further argument for the use of artificials in preference to securing available plant food by intensive cultivation, because of the comparative ease of providing such plant pabulum at the suitable period of growth by employment of the former. It may be pointed out here that the extensive use of fallowing practised in arid regions affords evidence of the recognition of the necessity for the upkeep of the humus content of the soil.

It is impossible to avoid partial destruction of the humus content of cultivated soil as a result of tillage operations necessary to secure a seed-bed and suitable tilth; it is not however necessary to push this cultivation so far as to destroy large proportions of the organic matter of the soil in all ill-advised attempts to make the latter perform the dual functions of providing plant food as well as soil texture. This partial destruction must be provided against by the use of organic manures, but the quantities of the latter

required to secure fertile soil conditions may be greatly reduced by the combined use of artificials; the plant food supplied by the latter will thus reduce or altogether abolish the necessity of utilizing the soil humus as a means of providing supplies of nitrogen, phosphates, and potash.

It may be suggested that, in view of the limited supplies of cow manure and oil-cakes available in India, more strenuous efforts should be made to extend the use of green manures throughout the country; much experimental work has been done on this subject, and in many parts of India the value of the method is well enough known to ensure its use, but the fact remains that over a large proportion of the arable area it is only occasionally practised. Several reasons exist for this failure to make use of such a valuable method of upkeep of soil fertility, one being the necessary loss of crop and another the frequent failure to obtain any obvious advantage from its use. It may be suggested that the methods of securing freedom from such failure which have been worked out in various districts should be given wider publicity and added to by further investigation; it may be noted here that one of these, well authenticated in Behar, is the use of superphosphate in conjunction with the burial of the green crop; this is an instance of the high value of an artificial fertiliser in Indian Agricultural practice and leads to the conclusion that there is no justification for the old established opinion that imported fertilisers can find no useful application for ryots' crops in this country. In any case it is important in the interests of the conservation of the soil humus that every effort should be made to introduce the practice of green-manuring wherever this is at present not in regular use, and that experiments should be carried out to ascertain the best methods of effecting this. It may be well to point out the advantages attaching to green-manuring as a method of upkeep of the soil humus as compared with the use of cow manure or oil-cake; the first method involves no capital expenditure, which, even in the case of cow manure is almost invariably required; supplies of cowdung and oil-cake are not always available, nor would they ever be sufficient to meet the requirements of the whole country even if the former were not mostly consumed as fuel. The introduction of a green leguminous crop in the rotation not only serves as a partial fallow but helps to eradicate undesirable weeds. All these reasons in favour of the use of green-manuring are well known to officers of the Agricultural Department and are only mentioned here to emphasize the importance of the original equally well recognized theorem at the beginning of this paper in view of the dangerous tendency to neglect the destructive effects of excessive cultivation upon the humus content of Indian soils.

Farmers in all countries hold certain opinions based upon experience and tradition rather than upon scientific knowledge or reasoning. Among such opinions no one holds a firmer or more universally agreed upon position than that which assigns to organic nitrogen a value considerably in advance of that with which its inorganic salts are credited. Experiments such as those carried out at Rothamsted on mangolds between 1876 and 1902 completely justify this attitude of mind so far as it applies to the substitution of inorganic or organic nitrogen, but also show, as Hall* points out, that the effects are due not to any intrinsic difference in the form of the nitrogen supplied but to the maintenance of the stock of humus in the soil associated with the use of organic nitrogenous manures. It is quite clear that to secure and maintain a condition of tilth in the seed-bed suitable for the early stages of growth of the seedling crop is of vital importance in India even more than in Europe, owing especially to the stringent conditions associated in this

*Hall, A. D. *Fertilisers and Manures*, p. 101.

country with the supply of moisture to the young plant. This suitable condition of physical texture can only be secured in the presence of adequate supplies of soil humus, which intensive cultivation sooner or later will inevitably reduce below the requisite level.

The object of this paper therefore is not only to urge the necessity of realizing the prime importance of organic matter in Indian soils, but to point out that the very generally inadequate supplies of this constituent are in danger of depletion, as a result of the introduction and recommendation of cultivation methods which increase the rate of its oxidation and general consumption; this method of obtaining increased fertility at the expense of the humus content of the soil is unsound in as much as it involves the utilization of this important constituent for a dual purpose, whereas part of this could be better fulfilled by the use of fertilisers, leaving the organic matter to carry out that function which it alone can perform by securing suitable mechanical texture in the soil. The practical interpretation of this argument lies in working out in the field suitable methods of combining the use of organic and inorganic manures, in such a way as to extend the existing supplies of the former over larger areas by their partial substitution by the latter. At the same time those fertilisers can be used to furnish part of the supplies of available plant food now being obtained by natural but wasteful processes, through the medium of cultivation and tillage.—*The Agricultural Journal of India.* Vol. XXII. Part 5, 1927.

Notes on Pineapple Cultivation.

THE following is an abstract of a paper read by Mr. L. A. Brunton, of the St. Augustine Experiment Station, at a Meeting of the Tacarigua District Agricultural Society, appearing in the *Proceedings of the Agricultural Society of Trinidad and Tobago,* Vol. XXVII. Part 7. July, 1927 :—

The Pineapple belongs to the family *Bromiliacae*; *Genus Ananas*, name *Anana Sativa.* Many species of this family are epiphytes, the pineapple is terrestrial, but may be considered as half an epiphyte owing to its ability to retain its vitality for months without being in contact with the soil. It is indigenous to the Western Hemisphere, mainly to South America, but its cultivation is now widely distributed throughout the world either in the open, under sheds, or in hot houses.

Climate.—A sub-tropical climate with alternating dry and wet seasous, a temperature of 70 to 80 degrees and an annual rainfall varying from 50 to 100 inches, is best suited to the growth of pineapples.

Soil.—The pineapple plant is not exacting as to soil, it will grow on soils of widely different character, from the coarse sandy pineapple soils of Florida containing 90 % of silica much too low in fertility for ordinary crops of vegetables or fruit, to the heavy clays of Hawai. The fact is that aeration is really the underlying principle of pineapple cultivation, consequently, any soil capable of being thoroughly aerated is suitable, provided the roots are supplied with a limited amount of water and the necessary plant food. Drainage is therefore the limiting factor, since a water filled soil excludes air. It will thus be readily understood why a deep, free, sandy loam is the ideal soil for this plant, such a soil is well aerated on account of its texture which ensures good drainage. It is easily cultivated so as to promote the retention of moisture during dry weather, and it is usually sufficiently fertile to produce crops, for some time at least, without the aid of fertilizers.

There are conditions other than that of the texture of the soil which may render a soil unsuitable to pineapple growing, but these need not be enlarged upon in this paper, beyond stating that investigation has emphasized the need of thorough aeration as a means of correcting most of these conditions, and that an acid soil is suitable, while an alkaline or neutral soil is totally unfitted for pineapple cultivation.

Propagation.—Plants can be raised from the seed, but besides very considerable variation in type it takes about three years for seedlings to bear fruit. It is useful for developing new types but impracticable for field cultivation. New plants are formed from buds which appear on the stem among the roots, in the leaf exiles, on the fruit stalk immediately below the fruit, and when the fruit is formed, on top of the fruit beneath and around the crown, these are known according to their position on the mother plant as ratoons, suckers, slips, crown slips, and crowns.

Ratoons and Suckers.—Ratoons are formed on the underground portion of the stem, they are soon independent of the mother plant as roots develop directly in the soil, they may be left to continue the field. Suckers develop above the ground from buds in the leaf axils, they will throw out roots which develop in the leaf axils of the parent if left in the mother plant, and will eventually bear fruit in that position even if severed from the mother plant, provided the plants are close enough to prevent them from being blown over. This is of practical importance as they can be retained to prolong the life of the field when ratoons are scarce. They make as good or even better plants than ratoons if root development has started, as the roots being single strands continue to grow when planted. Suckers are the commercial plant unless otherwise stated.

Slips originate from buds on the fruit stalk at the base of the fruit, they differ from ratoons and suckers as they cannot bear fruit while attached to the mother plant as they have no room for root development, if possible they should be left to develop for a few weeks after the fruit is reaped as they are usually too small for planting at that time.

Crown slips appear on the top of the fruit immediately below and around the crown, they are too small for planting in the field, but may be planted in nursery beds and allowed to develop until large enough for planting out.

Crowns are the rosette of leaves formed at the apex of the fruit, they are not desirable plants as they take about a year longer to mature their fruit than large suckers; when used it is essential that they should be large and mature as small immature crowns are subject to rot, they should be trimmed close to the base of the crown, and the cut surface cured by exposure to full sunlight for several days until it is hard and dry.

Stumps are the base of the old plants, from which a supply of plants may be raised by planting them in a continuous line in a furrow and covering with about 3 ins. of soil. It is claimed by some growers that plants thus raised are more vigorous than ordinary suckers.

Preparation of the Soil.—The essential of successful pineapple growing being aeration, it follows that soil must be brought into as mellow a condition as possible and thoroughly drained, but as a limited amount of water is also a requirement of the plant, very coarse sandy soils may require the addition of humus to conserve moisture, and as they are also deficient in plant food the application of fertilizers will be necessary; on the other hand clay soils require particular attention to drainage and the addition of humus to keep them loose and porous. Where the sub-soil is a heavy clay sub-soiling or sub-soil drains may have to be resorted to, even though the top soil is loose and porous. In short the soils in which pineapples are to be planted should be loose, porous, mellow, free from clods and well drained. This condition can be more or less successfully attained in most classes of cultivated soils, by ploughing and harrowing, or forking and hoeing, and turning under of organic matter, preferably in the form of a suitable cover crop previously grown on the land for that purpose.

The land should be thoroughly cleaned from all weeds before planting as weeding is difficult after the plants have attained a certain size, and cannot be done without some injury to the leaves, which should be avoided; land infested with nut-grass should not be planted with pineapples.

It is advisable before planting to apply a heavy mulch of grass, leaves, etc., to the soil, this will serve, not only to conserve the moisture and keep the surface soil loose and friable, but also to suppress the weeds until the plants have attained a sufficient size to enable them to shade the ground and protect it from the direct rays of the sun.

Planting.—Whether suckers, slips, or crowns are used, the plant should be prepared by trimming the butt end and stripping off the lower leaves for a distance of 1 in. to 2 ins. so as to expose the root buds, this is necessary to guard against the possibility of "Tangle Foot." The plants should be set in the ground 2 to 5 ins. deep according to size, taking care not to set them so deep that sand or earth can be easily blown into the heart as that will choke it; should it occur, however, the soil should be immediately washed out by pouring a stream of water into the heart, or it may be prevented by filling the heart with cotton-seed meal, dried blood, tobacco dust, or a mixture of any of these materials as soon as the plants are planted. This prevents the sand from entering, but unlike the sand does not choke the plant.

The pineapple's root system is shallow and does not usually extend over 6 ins. from the stem, in the larger varieties a few roots may reach to a distance of about 10 to 12 ins., but the main portions are closely matted together within a distance of 4 to 6 ins. It will therefore be readily seen that plants can be set as close as 12 ins. apart without root interference. The distance apart at which the rows should be spaced depends on the nature and condition of the soil, it ranges from single rows of 6 feet apart planted on ridges, to 20 or more rows 15 to 18 ins. apart planted on level ground, for instance, a coarse sandy soil with the ground water 2 feet below the surface and the lay of the land such that surface drainage is quick, can safely be planted in wide level beds; in fine sandy soil, or a sandy loam with imperfect drainage, the soil should be bedded up to a height sufficient to ensure good drainage, and if there are no noxious weeds to combat, the beds should be as wide as possible. In loam and clay soils, the beds should be narrower in order to ensure the aeration of the soil, the drainage in the shortest possible time of excess water, and the keeping of the soil free from weeds.

Single rows of 6 feet apart are not to be recommended, as the weight of the fruit causes the plant to lean over until the fruit touches the ground when it is liable to sun scald, and the field cannot be continued by means of suckers as these are liable to be blown off, the double row system remedies this defect somewhat, but many plants will, however, bend over when heavy with fruit. 3 to 6 rows closely planted eliminates this disadvantage as the plants support each other in a more or less upright position. Experience here indicates that three to four rows of 18 ins. apart and 18 ins. between the plants in the row is a suitable and convenient method, the plants cover the ground quickly protecting it from the direct rays of the sun thus keeping the soil loose and friable, and keeping down the weeds, the fruit can also be picked from the paths without stepping on to the beds, which cannot be done with a six-row bed, the centre rows being inaccessible from the path. Whatever width of bed is adopted, paths at least 6 feet wide, preferably 8 feet, should be left between them, to enable the work of cultivation and reaping to be carried on.

Cultivation.—If the soil has been properly prepared before planting and all noxious weeds destroyed, very little cultivation will be necessary to the growing plant and very little weeding, if a good heavy mulch was applied before planting. Anyway the objects to be borne in mind are, to keep the soil free from weeds and the surface loose and open, so as to conserve all moisture during dry weather and encourage rapid percolation during rainy weather. It must however be borne in mind that owing to the shallow root system cultivation must not be deep especially close to the plant, and when fertilizers are used great care should be exercised not to pull the soil away from the plant as in doing so the fertilizers may be drawn outside the radius of the roots. One other very important caution is necessary and this is,

whatever operations are performed to the growing crop, the greatest possible care must be exercised not to injure the leaves; a broken leaf soon loses moisture to so great an extent as to result in serious damage to the plant.

Fruiting.—Many factors are responsible for the time required to produce fruit, some are controllable such as the size of the plant, cultivation, fertilization, but climatic conditions are uncontrollable. Large suckers, ratoons and vigorous slips 12 ins. long, will fruit in one year or less under favourable conditions, but the fruit is smaller and not of such good quality as when fruiting takes place in 16 to 18 months. It is not easy to describe the proper degree of ripeness for gathering the fruit, this will also depend on the length of time before the fruit reaches the consumer. Experience will prove the surest guide, but indications of ripening are, the crown opens out, the eyes flatten, the margins round up, the space between the eyes opens and grows lighter in colour, and the little leaflets will, then shrivel. As a rule the quality of the pineaple will be better the more nearly it is ripe before being picked.

Life of the Field.—It is not yet possible to say how long the life of a pine field may be profitably continued, but the indications are that three to four crops can be reaped before replanting is necessary.

Diseases and Pests.—Unfortunately, as with all cultivated crops reference to the diseases and insect pests to which the crop is liable must be made. The fruit is generally subject to the attack of caterpillars, especially during the dry season and some measure of control can be secured by spraying with Bordeaux mixture. Fruit-rot or Fruit-let spot, is another disease which attacks the fruit but not very seriously. It is most likely to appear during rainy weather but as it shows no outward indication in its early stage it is difficult to detect and in fact is only detected upon cutting the fruit. A White Leaf spot due to the fungus *Thielaviopsis Paradox* has lately appeared on the leaves, but cultural methods together with spraying with Bordeaux mixture appears to keep it in control.

Tangle-Foot has already been mentioned, it is the wrapping of the roots round the stem, and is usually due to not stripping the lower leaves before planting, the roots being unable to penetrate the tough leaf take the line of least resistance and grow round the stem; it may also be due to a hard clay soil. The remedy is obvious, correct the conditions. Sun scald—when one side of the fruit is exposed to the direct rays of the sun and moisture adheres to the fruit, the sun's rays induces premature ripening and scalding at that spot, rot soon develops in the scalded part. This can be prevented by covering the fallen fruit with a handful of dried grass.

Cross-Breeding and Grading of Cattle in India.

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IT has long been an understood fact that cross-breeding as well as in-breeders, when used as a reguar practice, is detrimental. Our master breeders used both these methods only as a means to an end of the establishment of our present-day breeds of cattle of the West. The same must be done if we wish to establish a breed of cattle in a short period of time which will be supreme in milk-producing and disease resisting qualities. In general cross-breeding is defined as the mating of individuals which are not related, but as a rule cross-breeding means the mating of individuals belonging to different breeds or the union of animals belonging to different species.

As in-breeding tends to simplify the germ-plasm and strengthen the powers of transmission, cross-breeding tends to weaken the prepotency and complicate the elemental constitution of the hereditary substance. Crossing has a tendency to break up established characters. It destroys combinations of characters which have long existed in the strains and which under the system of pure breeding have behaved in a manner like unit characters in transmission. Because of this, cross-breeding cannot be carried on indefinitely. It does, however, serve a good purpose in the starting of a new breed. The very fact that crossing disturbs the balance of characters and brings about recombinations in the germ-plasm gives it a peculiar value in causing variations to appear.

The breeder who is working with pure-bred animals which owe their purity of breeding to a long period of careful selection by skilful breeders cannot hope to cause any great degree of improvement. Pure-bred animals are already improved. About all any breeder working with pure-bred animals can do is to select out the highly desirable strains from those of lesser value already in the breed. But, as Johanssen has shown, there are very definite limits beyond which the improvement of pure lines cannot go. If Indian breeds could be improved to the high degree of efficiency of the Western breeds in a reasonable length of time then pure line breeding would be well worth while. There may be three or possibly four indigenous breeds which could be bred to a fairly high degree of milk-producing efficiency in a reasonable length of time and this should certainly be done, but it is very doubtful that any Indian breed will reach the high degree of efficiency of our major dairy breeds of Europe. Marked improvement must come through variation. Crossing is a common cause of variation. Variations which appear as the result of crossing may be desirable or undesirable. Desirable variations may be perpetuated by in-breeding ar a new and valuable quality may be secured in this way.

There are two methods that may be followed after the first cross. The first method is the practice of grading after the first generation from two different breeds have been attained. The continual mating of pure-bred bulls to the first generation and to all the generations that follow will gradually develop a type identical to the breed the sires represent.

The second method is the practice of again crossing members of two separate families which are the first generation of two separate breeds. By applying Mendelian principles, which will differentiate the qualities of an animal and will determine their behaviour in transmission, the practical breeder will then carry on breeding methods upon the principles of segregation and dominance which are the foundation stones in the theory of Mendelian inheritance. Just a start in this second method has been made at the Lucknow Military Dairy and some very hopeful results have been reached so far. In this article, however, we will take up what has been accomplished through the first method at the Lucknow Military Dairy. Colonel Matson, Assistant Controller of the Military Dairies of the Southern Circle, has very kindly allowed me to make use of this information in any way for the advancement of breeding in India.

The first method was the method adopted in America. The Americans benefited by all that Europe built up through scientific breeding. They imported pure bred animals from Europe and mated them to native or unimproved animals. By the continuous use of pure-bred sires many high-producing animals of different breeds were established. This method unfortunately has proved unsuccessful in India as far as the Ayrshire is concerned. This fact is well recognized by the Military Dairy authorities who have done the most extensive work in cross-breeding in India. The main reason for the failure of the Ayrshire is due to the fact that it has not the characters which will blend with the characters of the Indian breeds on which it has been tried in the making of a progeny which will have constitution as well as good milking qualities in the second and third generations. Just how far this will apply to all the other European breeds is yet to be seen. However, it may be said that the Holstein-Friesian breed has so far surpassed the Ayrshire breed.

The $\frac{3}{4}$-Ayrshire is very inferior to the half-bred Ayrshire and the $\frac{7}{8}$-Ayrshire is a hopeless animal both from the point of breeding as well as a milk producer. The $\frac{3}{4}$-Friesian has proved to be a superior animal to the half-bred Friesian. Just how far the Friesian can be used for grading-up purposes is not yet known. The $\frac{7}{8}$-Friesian-Hariana grades are proved to be animals of good constitution and good milkers. Colonel Matson showed me many cases at the Lucknow Military Dairy to substantiate the above statements.

A cow in the Lucknow herd named Carnation has 25/32 European blood, of which 24/32 is Friesian and 1/32 Shorthorn. The remaining 7/32 is Hariana. She has an excellent dairy conformation, a good constitution, and gave 10,000 lb. milk during her first lactation period at three years of age. Carnation's granddam, on her dam's side a $\frac{1}{8}$-Shorthorn-Hariana cow, only gave an average of four pounds of milk per day, which goes to show that the pure-bred Friesian sires in the third and fourth generations were responsible for this excellent animal. It will not be surprising if Carnation makes a record in milk-production for all India at the end of her fourth lactation. It is doubtful if any three-year-old cow in her first lactation has done so well, up to this time. Carnation's half sister, Gwendolyn, has 25/32 European blood, 16/32 of which is Ayrshire, 8/32 Friesian, and 1/32 Shorthorn. The remaining 7/32 is Hariana. She has a very poor constitution and gives a very small amount of milk. Colonel Matson attributes this to the Ayrshire blood.

A fairer comparison, however, between the Freisian and Ayrshire breeds can be shown where both breeds were crossed to the same Indian breeds and where only two lines of blood were used in both cases. The half-bred animals in both cases are always good, although the Friesian half-breds invariably gave more milk than the Ayrshire half-breds.

The Friesian-Hariana half-breds and grades average 10,000 to 15,000 lb.
The Ayrshire-Hariana half-breds and grades average 3,000 to 9,000 lb.
The Friesian-Sahiwal half-breds and grades average 8,000 to 10,000 lb.
The Ayrshire-Sahiwal half-breds and grades average 3,000 to 9,000 lb.

The $\frac{3}{4}$ and $\frac{7}{8}$ Friesian-Hariana and the $\frac{7}{8}$ Friesian-Sahiwal always proved to be far superior in constitution and in milk production to the $\frac{3}{4}$ and $\frac{7}{8}$ Ayrshire-Hariana and the $\frac{3}{4}$ and $\frac{7}{8}$ Ayrshire-Sahiwal. Janet, a $\frac{3}{4}$-Ayrshire-Hariana grade, gave about 2,900 lb. of milk in her first lactation, while Abigail, a $\frac{3}{4}$ Friesian-Hariana grade gave about 4,900 lb. of milk in her first lactation. Many more instances like the above go to prove conclusively that the Friesian is superior to the Ayrshire in crossing and grading up with the Indian breeds. The Friesian not only transmits its milking qualities to its offspring but its characters blend rather than conflict with the characters of certain Indian breeds, so that the progeny do not lack constitution as in the case of the Ayrshire grades.

Camella, a 15/16 European cow, of which 10/16 is Friesian and 5/16 Ayrshire, leaving only 1/16 country blood, gave a 42 lb. daily average during her first lactation at three years of age. She is a fourth generation cow, and in spite of the fact that the Ayrshire was used as the foundation bull and was used again in the second generation, the Friesian blood was strong enough to produce a cow with a strong constitution and a capacity for milk-production. It so happens that the Ayrshire-country $\frac{3}{4}$ and $\frac{7}{8}$ grades fall off badly in constitution; and milk production aways falls off accordingly. Although according to Galton's law there is only twice as much Friesian blood as there is Ayrshire in the cow Camella, yet it is quite possible that there may be more Friesian blood represented in her, knowing what we do to-day about the make-up of the germ-plasm. In the Lucknow herd $\frac{7}{8}$ Ayrshire-country grades having poor constitutions were crossed with Friesian bulls and the progeny were quite often good, which seems to bear out the point that the Friesian blood in the cow Camella was responsible for her good record. It was Colonel Matson's opinion last November that the Ayrshire was a complete failure as far as using it for grading purposes in the tropics was concerned.

A very interesting experiment of crossing half-bred cows to country bulls showed that the progeny were poor milkers but when country cows were crossed with half-bred Friesian bulls the progeny turned out to be good milkers. This seems to indicate that the sires in both cases were more repotent than the dams, in spite of the fact that in the second case the sire was a half-bred Friesian. When $\frac{1}{4}$-European cows (Friesian or Ayrshire) were crossed with country bulls the results were poor, giving a $\frac{1}{8}$ cross averaging 6 lb. daily. When the same cows were crossed with a $\frac{1}{4}$-Friesian bull the results were good; when crossed with pure Friesian bulls it gave $\frac{5}{8}$ crosses averaging 28 lb. daily. The $\frac{1}{4}$-Friesian bull had to have a half-bred Friesian bull as a sire. He could not be the descendant of a country sire and a half-bred Friesian dam in order to make any improvement. This all goes to prove that if one knows the breeding of his Friesian bulls, even if they are not pure-bred, he can get fairly good results. Of course it is always safer to use the pure-bred animal. If, however, the Holstein-Friesian proves to be worth while for grading purposes, it would be better for a beginner to start with a grade-bull and then to follow up with a pure-bred Friesian bull rather than delay until he can afford to buy a pure-bred Friesian bull.

The best indigenous herd in India, which has been developed through careful selection for many years, has obtained an average of about 8,000 lb. of milk per year. The foundation cows for this herd were obtained from great distances and were most carefully picked. Are we satisfied with an 8,000 or 10,000 lb. average? Yes, at present, we are, but in the future we will not be. We must strive for higher levels, and I am doubtful if any indigenous breed even after many years of pure-line breeding will pass the 8,000 to 10,000 lb. level.

It may be that this first method of grading with pure-bred Holstein-Friesian bulls as well as with other European bulls that have not been tried may prove unsatisfactory. In that case as far as using this method as a general policy to be recommended for all would be unwise. However, we must wait and see how the experiments now being carried on turn out before any general policy for cattle breeders can be determined.

Experiments in the second method will take many years to work out. In the long run, however, a breed which can be produced according to Mendelian principles is sure to be satisfactory. It will take expert supervision and a great deal of time and money, but it would be time and money well spent.—*The Journal of the Central Bureau for Animal Husbandry and Dairying in India.* Vol. I. Part 3.

Errors in Feeding Live-Stock.

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DURING the past 25 years, hundreds if not thousands, of papers have been published, many of them containing facts and observations each of which has added a little to the sum of our knowledge of the laws of nutrition of farm animals. It would, I suppose, be within the bounds of possibility to give a detailed catalogue of these individual papers, setting out the salient points of each. Such a proceeding would take a very considerable time, and would be quite useless to the farmer, although valuable to the investigator. Indeed, every investigator before he starts his investigation makes such a catalogue in his special line of work, either on paper or in his own mind, in order that he may experiment in the light of other people's results.

I myself have read many of the papers on nutrition published during the past 25 years, and what I propose to set out is the general impression of the practical value of nutrition research which their perusal has left in my mind. It will of necessity be a personal impression—another writer might stress different points—but I hope it will be useful to the practical man, as it has been to me, not only in the conduct of my own research work but in the rationing of the animals on my own farm.

Traditional Methods are Wrong.

My first impression, and I do not think this particular point is open to argument, is that the great majority of owners of live-stock who feed their animals on traditional lines, are wrong in the following particulars :—

(1) They include too much protein in the rations of their fattening animals.

(2) They include too much protein in the ration of their working animals.

(3) They do not give enough protein to their young growing animals.

(4) They do not give enough protein to their milking animals.

(5) They do not give enough ash constituents of the right kind to their growing animals and their milking animals.

Points 4 and 5 are, however, not within the province of this article. They have been dealt with already by Mr. Mackintosh, of Reading, Dr. Orr, of Aberdeen, and Dr. Crowther, of Harper Adams College; consequently, I do not propose to discuss them further. The remainder of this article will be devoted to discussing points 1, 2 and 3.

Protein for Fattening Animals.

The usual method of feeding fattening animals, namely, to give them roots and straw or hay, supplemented by a generous ration of oilseed cakes, has been handed down traditionally from the time when it was started at the close of days of the great landlords 70 or 80 years ago. It originated from the work of the first chemists who turned their attention to agriculture, and concluded, on grounds which have subsequently been found to be wrong, that fat could only be produced in the animal body from fat or oil and protein. Oilseed cakes, being rich in both these constituents, seemed excellent for fattening, their use became general, and the custom has lasted.

It is about 70 years since Laws and Gilbert showed that most of the fat formed in the body of a fattening animal was formed from carbohydrates, such as starch and sugar; but this observation, although accepted by physiologists, is only just beginning to find its way into agricultural practice as the result of more recent research.

Recent accurate research on this subject dates from Kellner's measurements of the fat-producing power of proteins, oils and carbohydrates, which showed that proteins were distinctly less effective fat-producers than either of the other recognized constituents of feeding stuffs. Still more recent work has shown that full grown animals required much smaller amounts of protein than most rations provide, and that increased supplies of protein in the case of such animals do not raise the rate of live-weight increase.

The amount of digestible protein required by full grown animals on full fattening rations is well known. It is, for a full-grown or approximately full-grown steer, not more than $1\frac{1}{2}$ lb. of digestible protein per day; for a full-grown sheep not more than $1\frac{3}{4}$ lb. of digestible protein per week. These quantities are usually greatly exceeded. The excess does no harm to cattle, except, of course, that its provision entails wasteful expense. In the case of sheep, an excessive supply of protein is apt to cause death through failure of the kidneys.

Protein for Working Animals.

As with fattening stock, so with working animals, the traditional idea is that protein is the source of masculine energy. This is not true, and there is no need to increase the protein in the ration of an animal because it is required to do hard work. It is unfortunate, however, that no important additions to our knowledge of the protein requirements of the horse have been made in recent years.

Protein for Young Animals.

It is desirable that a young animal should grow, and consequently that it should increase in weight. The food requirements of the growing animal are to a very large extent governed by this fact, since they must not only keep the animal alive, but must provide the material of which the increased weight is composed. In recent years much work has been done on this subject, the gist of which is that the increase in live weight made by a young animal consists mainly of water, but contains considerable quantities of protein and ash. It is noteworthy that a young, rapidly growing animal usually puts on very little fat.

Protein being the most abundant constituent of the live-weight increase of young animals (of course excepting water), it follows that a young animal requires a liberal supply of protein in its ration. Traditional practice does not give this, especially in the case of cattle. As a rule, young stock are wintered on poor pasture with perhaps a little poor hay or in yards on poor

hay or even straws and a few roots. They would do very much better and so would their owner, if they got some of the cake which is so often wasted on fattening cattle and sheep. This fact is beginning to meet with some measure of recognition, especially in the production of "baby" beef fat lambs and pigs which are ready for the factory at six or seven months old.

Computing Rations.

My next point is that the knowledge which has accumulated as the result of the research work carried out during the last 25 years makes it possible to compute a ration which will produce any desired result within the possibility of the animal which is to consume it.

For some time past, advanced milk producers have adopted the method of basing their rations on the principle of maintenance ration *plus* an additional allowance per gallon of milk. In much the same way it is possible to compute rations for young growing animals or for fattening animals on the basis of maintenance ration *plus* an addition for each pound of live-weight increase which it is desired to produce.

The essential points of rationing on this system are:—(1) That an animal's appetite is limited—a full-grown steer, for instance, will not eat more than about 25 to 30 lb. of food per day, weight in the dry state. (2) That a large part of this food is required simply to keep it alive—this is the maintenance ration—and its amount, measured by modern experiments, is given in the books referred to above. To this maintenance ration must be added so much real nutritive value per lb. of increase expected.

The more increase one expects, the more real nutritive value it is necessary to get into the limit of the animal's appetite; which means using highly digestible foods such as cakes, corn, meals and roots for the productive part of the ration. For young growing animals requiring much protein, a good proportion of cake is desirable. For adult fattening animals, corn, meal, and roots are cheaper and more suitable.

Starch Equivalent.

It is usual to measure the real nutritive value of feeding stuffs in terms of their starch equivalent as determined by the method of Kellner. The weight of starch equivalent required to produce 1 lb. of increase in animals of various classes has been found from the results of modern research on the composition of the carcases of animals. This method of computing rations is a distinct advance on the methods hitherto in use. When it gets absorbed into the general practice of farming it will correct the common errors in feeding noted above, and will add materially to economy in animal production.—*The Quarterly Journal of the Board of Agriculture of British Guiana*, Vol. XX. No. 3. July, 1927.

Preservation of Whole Fruit with Sulphur Dioxide.

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SULPHUR dioxide, as well as its various compounds, such as bi-sulphite of potash, bi-sulphite of lime, has long been used for the preservation of wines, beers, fruit beverages, and various articles of food. Sulphur dioxide has also been employed to some extent for the preservation of fruit pulp.

At the suggestion of the Fruit Branch, some experiments were recently carried out at the orchard of Hawkesbury Agricultural College with a view to determining if whole fruit could be suitably preserved under local conditions by the use of dilute aqueous solutions of sulphur dioxide. Similar experiments were sometime ago carried out by Baker and Grove at Campden Fruit Research Station, Glos., England, and are described by those workers in a recent issue of the *Journal of Pomology and Horticultural Science* (Vol. V, No. 1, December, 1925). In the experiment referred to satisfactory results are reported as having been obtained in the preservation of raspberries, blackberries, strawberries, plums, and other fruits by the use of this preservative.

The following is a brief report of Preliminary trials at Hawkesbury Agricultural College, and of the results obtained so far with plums and grapes.

Trial with Plums.

Trials with plums were commenced on 13th January, the variety used being Cyca Smomo (a blood plum). Half-gallon screw top jars were used, being filled with fruit of uniform size and maturity.

Aqueous solutions of sulphur dioxide, with concentrations of 0·08, 0·09 and 0·10 per cent. respectively were prepared. These solutions were poured over the fruit contained in three separate sets of jars, which were subsequently labelled sets 1, 2 and 3. After the solutions had been added the jars were tighty sealed, and the contents examined a week later. All the fruit was found to be in good state of preservation, but the skin had become considerably bleached.

The contents of sets 2 and 3 developed strong acidity, while the fruit in set 1 was only slightly sour. A further experiment made two months later showed that the fruit in all the sets was still fresh and sound, and that no fermentation had occurred, but it was still sour, and the skin as well as the flesh had undergone considerable bleaching, so that the latter was now a faint pink colour.

An attempt was then made to see whether cooking would restore the fruit to its natural colour, or diminish its acidity, the tests being :—

(a) By heating a portion of the fruit in an open boiler.

(b) By steaming a portion while still in its container.

In both cases it was found that the natural colour of the fruit was partly restored by these methods, and that the acidity was considerably reduced. The restoration of the colour was more complete when the cooking was done in an open boiler than when in its container.

The experiments would seem to indicate so far that 0 :08 per cent. sulphur dioxide solution was sufficiently strong for the preservation of the variety of plums tested, but it would appear desirable to try the effect of lower concentrations, say, :06 and :04 per cent. of sulphur dioxide on these and other varieties of plums. It is proposed to do this next season.

Trials with Grapes.

Experiments with grapes were also carried out. Four varieties were selected, namely—Gros Moroc (black grape), Gros Guillaume (black grape), Flame Tokay (pink grape), Waltham Cross (white grape).

On 24th February, 1927, three 1-quart jars of each variety were prepared and covered with the preservative solution, as in the experiments with plums. It was thought desirable in the case of grapes, these being more delicate fruit, to try the effect of a more dilute solution of sulphur dioxide. With this end in view, concentrations of 0 :08, 0 :06, 0 :04, 0 :01, and 0 :08 per cent. of sulphur dioxide, which was labelled Nos. 1, 2, 3, and 4 respectivey, were used.

The fruit was examined on 10th March, and it was noted that Nos. 3, 4, and 5 had undergone more or less fermentation. In the case of Nos. 1 and 2, no fermentation could be detected, but bleaching of the skins in the case of the coloured grapes had occurred. The natural flavour of the grapes had been retained.

On 1st June (over three months after the fruit had been preserved) cooking experiments, on similar lines to those adopted with the plums were carried out with Nos. 1 and 2, and the original colour of the black grapes was partly restored, but no change took place with the Flame Tokay variety. It remains quite bleached.

An interesting point was noticed with the black grapes. A control jar of grapes that was not cooked, but of which the lid was left, in twenty-four hours developed a similar colour to that of fruit that had been cooked. The probable explanation of this, and of the colour changes obtained when the fruit was cooked, is that the sulphur dioxide has a slight reducing effect on the natural pigment found in the fruit, and on the removal of the excess sulphur dioxide, which is brought about when the fruit is heated or simply aerated, a re-oxidation of the pigment substance occurs, and the fruit is restored wholly, or in part to its natural colour.

The changes observed naturally lead one to enquire whether, apart from its preservative action, sulphur dioxide has any direct chemical effect on other constituents of the fruit. In connection with this point it is interesting to note that some studies—vide *Journal of Pomology and Horticultural Science*, Vol. V. No. 1, December, 1925—has been carried out lately by Appleyard at the Campden Research Station, England, dealing with this aspect of fruit preservation with sulphur dioxide. It was found that the enzymes present in the fruit were inactivated by treatment with the preservative, just as such enzymes are inactivated or destroyed when the fruit is boiled during the process of manufacture into pulp. It has also been observed that the fruit so treated undergoes some loss in "jelling" powers when used in the manufacture of jam.

Further trials with different fruits and varieties are necessary in order to determine how far the method described is applicable and practicable under Australian conditions. If it should be found from subsequent investigations that ordinary varieties of Australian-grown fruits could be satisfactorily preserved in this way, this process would seem to compare more than favourably with other methods of fruit preservation in common use. It would, for example, allow of fruit being kept and marketed in a more attractive form than when it is reduced to pulp.

Apples, for instance, could be preserved whole or in sections, instead of being reduced to pulp, and the product would probably command a higher market value. Moreover, the preserved product could be used as an article of food in the same way as bottled or canned fruit, and the labour and time involved in its preparation would be considerably reduced. In addition, surplus fruit obtained during a glut season could be stored and profitably utilized for jam manufacture, the labour and time involved in its preservation being less than that required to preserve it, as at present, in the form of pulp.—*The Agricultural Gazette of New South Wales,* Vol. XXXVIII. Part 2., 1927.

The Artificial Colouring of Citrus Fruits.

D. B. FERGUSON.

IT must be obvious to all that well coloured oranges and lemons will command a higher price on the market than those in a semi-green state. This would apply to a much greater extent on the Southern markets.

Queensland growers no doubt realize that their fruit is fit for domestic purposes many weeks prior to attaining the degree of colouring that the market desires. Citriculturists who have had experience in various citrus-growing localities will agree that oranges grown in the cooler regions have ample colour long before they attain sufficient sugar to make them desirable for eating purposes, while those produced in warmer climates are sweet and luscious for some time prior to taking on the deep orange appearance which commands the higher price on the market. There is ample room in the Southern States for the production of fruit for the late market, and as the producing cost is somewhat less in those districts, the Queensland grower would be well advised to devote his attention chiefly to he supply of early fruit, and consequently he would reap the advantages of the high prices prevailing in the early part of the season. Hundreds of bushels of sweet oranges can be found in our groves during the month of April, and if these had colour together with a freedom from blemish, sugar, juice, and an attractive pack, all of which are features which command higher prices, they would be worth up to 30s. a bushel during that month and also the month of May.

Method.—Oranges and lemons, provided they have reached a state of maturity, can be coloured with very little expense in a short space of time.

A gas-tight room is required; in size it may be large or small. This would depend upon the quantity of fruit which the grower desires to colour each four or five days. It need not be an expensive structure; the roughest of timber would serve, provided it was lined with paper or any material which would prevent the escape of gas. The fruit, after being harvested, is placed loosely in lug boxes. A size which is capable of holding about a bushel is the most convenient. It is essential, however, that these are of a design which will allow the gas to circulate around the fruit when the boxes are stacked one on top of the other. They may be constructed with spaces between the boards on the side, with lugs across the top which will prevent one box from sitting tightly on top of another. The ordinary kerosene case could be used satisfactorily if opened on the side and 2 by 1 in. slats attached at each end of the opening. There should be a space of two inches between each stack of boxes and the wall to provide space for the gas to move freely. The next procedure is to produce the colouring agent. Any form of carbonic acid gas will do. This in California is put up commercially in cylinders, but prior to this recent development the

exhaust from a motor and the burning of kerosene lamps were the general methods adopted for the production of gas. If the motor is used a pipe is taken from the exhaust and passed into the colouring chamber through a hole in the wall. If lamps, it is merely a matter of burning the ordinary kerosene wick type.

A chamber of 20 ft. by 20 ft. by 12 ft. high would require three of the circular burner type of lamp similar to those used in the kitchen. These of course, can be purchased, less fittings, and are not an expensive item. In short, it is replacing the oxygen in the chamber with carbon monoxide and carbon dioxide which brings about the change in colour.

The time required is from three to five days. The writer is in doubt as to whether it is known actually what happens within the tissues of the rind. The process, however, has no ill effect upon the pulp of the fruit.

In order to preserve the keeping qualities, it is advisable to avoid atmospheric moisture and also keep the temperature as low as possible. After the lamps have been burning for some time, they will go out. This is due to the absence of oxygen in the air—that having been burnt—but the colouring process continues.

They should be relighted twice daily. The lamps should be prevented from smoking, as this causes soot to settle on the fruit which is somewhat difficult to remove.

Market Standard.—There are periods in the year when the lemon market becomes glutted, and it would naturally follow that lemons were most plentiful. Green fruit will keep considerably longer than that in a ripe state. In localities where fruit will keep a grower may overcome the glutted market problem by harvesting immediately the crop reaches maturity and storing until prices are better, when the fruit can be quickly coloured and placed on the market. In different parts of the world where this treatment has been practised, it has also been abused in some cases, in that fruit in an immature state has been coloured and forwarded to the consumer. This, of course, has a detrimental effect on the industry generally. It is rather lamentable that such growers should exist. The difficulty, however, was overcome in California by setting a sugar standard for all oranges going to the market.—*Queensland Agricultural Journal,* Vol. XXVIII. Part 4.

The Art of Applying Fertilizers.

Bringing Food to the Plant.

GREAT losses are often sustained by farmers because they do not apply their fertilizers properly. Plants take in through their roots food and water. These are essentials, and the degree to which they are available will determine largely the extent to which the roots will develop and penetrate into the soil.

Allow Roots to Penetrate Sub-Soil.—The fertilizer contains plant foods, and if it remains in the top layers of the soil or on a narrow strip near the surface, the roots of the plant will also remain there, near to the food supply, and will not penetrate into the lower layer or even distribute themselves properly through the surface soil. As long as moisture conditions are favourable, such plants will make vigorous growth, but should drought come they will be injured much more severely than if they had an extended root system which would then have drawn on the moisture stored lower down.

Rainfall and Method of Application.—The soluble parts of the fertilizer are washed into and distributed through the soil by rain water to an extent depending upon the rainfall. Insoluble material will remain where it was deposited until distributed by the plough or some other implement. Where the rainfall is good the plant food will naturally be thoroughly distributed, but in areas with a scanty rainfall, or in droughty years, this natural distribution frequently does not take place, so that if the fertilizers had been only applied to the surface or applied by means of planters and not ploughed in, the consequences may be serious.

How to Apply Fertilizers.—To avoid certain dangers and difficulties the farmer must assist the distributing forces.

It is always best and safest to broadcast any fertilizer and work it in by means of plough, disc, or harrow on any soil under any climate. In the drier areas the fertilizer must be broadcasted and not planted in any circumstances. Where rainfall is reasonably high and certain, planting may perhaps be resorted to, especially if fertilizers have been used on the soil for some time previously, but even in such areas broadcasting is more satisfactory and safer because :—

(1) There will then be no danger of poor distribution and consequent bad effects should a dry year eventuate,

(2) Fertilizer applied by means of the planter is concentrated in the vicinity of the young tender seedlings which are thus frequently injured by the soluble salts and acids, a danger greatly minimized by broadcasting.

When to Broadcast Fertilizers.—Broadcasting should be practised wherever possible, especially with all insoluble fertilizers such as bonemeal, manure and rock phosphates, because these substances are not distributed by rainwater.

Broadcasting can be done by hand or by implements specially made for the purpose. Fertilizers that contain their plant foods in the soluble form should be broadcasted shortly before the land is planted; or sown and then ploughed, disced, or harrowed in. Insoluble fertilizers as mentioned above, should always be applied and worked in as long as possible before the next crop is put in.

After the fertilizer has been broadcasted it can be worked in by any method: it can be put on before the land is ploughed and then ploughed under, or broadcasted on the ploughed land and then disced or harrowed in.—*The South African Sugar Journal.* Vol. II., No. 10, 1927.

The Rearing of Chickens.

WILLIAM A. BARTLET.

AT this season of the year, the thoughts of all poultry-keepers naturally turn to the question of chicken rearing, for upon the success or otherwise of this important part of their duties depends the future well-being of their undertakings.

The first essential is to see that all incubators, brooders, etc., are in tip-top order in every way, the greatest possible attention being paid to ensure that every part of the outfit be scrupulously clean, before commencing operations. Incubators are mentioned, although outside the limits of this article, because chickens from a dirty incubator can never be successfully reared.

Chickens may be reared naturally, *i.e.*, with the mother hen. If this method be adopted, the hen should be dusted with some infecting powder before being set and again a couple of days before the chickens are due to hatch. A good powder can be cheaply made by thoroughly mixing 1 lb. sodium fluoride, 1 lb. flowers of sulphur, 1 lb. of tobacco dust and 1 lb. of air slaked white lime—the two latter being first run through a very fine sieve. After mixing in a basin, the whole lot should be run through the sieve as this helps thorough mixing. This powder may be used for dusting fowls of any age, and it is most effective. If the mother hen be troubled with scaly legs, these should be thoroughly washed with soap and water, and thereafter painted with carbolineum, using a brush with hard short bristles. A "Glory" brush is just the thing. The feeding of the naturally reared chicks can be the same as those reared in a brooder, but the chick food should be protected in such a way that only the babies can get the more expensive diet.

Feeding.

Chicks should not be fed for at least 48 hours after hatching—it is quite safe to leave them without food for 72 hours. The reason for this is that the last act of the chickens before leaving the shell is to absorb the yolk of the egg into its body through the naval. The yolk-sak is connected with the stomach by a vein-like duct through which the liquid yolk flows as required for the upkeep of life. Nature has provided that as soon as the flow ceases the duct and yolk-sak are dissolved and absorbed into the system of the chicken. If fed too early, and especially if such food as hard boiled eggs be supplied, there is no call made by the stomach on this natural supply, with the result that the flow of yolk ceases, absorption of the duct takes place, leaving the unconsumed portion of the yolk in the body of the chicken. There being now no outlet for this mass, it quickly becomes putrid, inflammation in an acute form is set up, while diarrhoea appears, the chicken droops and in nine cases out of ten, dies. Since the longer period before feeding has been adopted (it used to be 24 hours) and the total elimination of hard boiled eggs from the menu, white diarrhoea has been practically unknown among the chickens in my yards.

The first feed is pine-head oatmeal placed on clean river sand. The oatmeal is slightly moistened with sweet milk, but not sufficiently so as to make the grains cling together. It may be here mentioned that the cement floor is covered with clean river sand to the depth of about three inches, and this is the only covering used. The chickens seem to thrive in this better than with a covering of either wheat chaff or grass. The morning drink for the first four days or so after feeding has commenced, is a weak solution of sweet milk and water. Clean water is available during the rest of the day in vessels so constructed that the chickens cannot drown themselves.

After a couple of days' feeding with the oatmeal, and chick grain alternately, dry food is kept before the chickens from early morning to 2 or 3 p.m., when the hoppers are either closed or removed. A small quantity of finely crushed grains is thrown to the chickens occassionally to keep them busy, as this helps to prevent toe-picking, but the big feed of grain is given shortly before sun-set, so that the chickens go to roost with bulging crops, as this carries them through the long night. Any grains left over are eagerly dug for in the sand at the first glimpse of daylight.

At the close of this article, the mixtures used for the various ages are printed. They are simple, comparatively cheap and have given excellent results for a considerable number of years. In addition to these mixtures, a supply of fine charcoal, shell and grit is kept where the chickens can get them. Green food is also fed daily, sprouted oats being always available if other greens fail. After the first week, sour milk is given as a drink every morning, and is greatly relished, and does much to build up a strong virile chicken.

Now, as regards brooding. Cold brooders are quite excellent for the rearing of chicks in small numbers, and there are many types of these brooders both on the market and to be seen in poultry yards. With large numbers of chickens, however, artificial heat certainly reduces labour and attention. The warmth attracts the chicks, and they run to the brooder if they feel at all chilled. On the other hand, in the cold brooder, there is no such attraction, as heat is only generated after the chicks have been for some time in the brooder. This means that the poultry attendant has to drive the little babies in and let them out to feed and water at frequent intervals, especially in cold weather, thus giving extra labour and time.

If coal brooders be used, and they are becoming more and more common every year, be careful to use only anthracite coal, as the ordinary variety gives off sulphurous and other fumes to such an extent that the chickens are slowly gassed, and drooping wings and listlessness generally soon become apparent. Again, a cool brooder tends to make the air very dry, and it is useful to have a stand for sprouting oats in a corner of the brooding house, as moisture is taken up from them into the atmosphere, and prevents attacks of bronchitis. A paraffin tin or two of water placed in the room also helps. (I have not gone into details of hot water brooding, as those using this method, probably know more than I do about chicken rearing by this method.)

Direct sunshine is absolutely essential to successful effort. Special glass is being used in cold countries to allow the ultra spectum rays of sunshine to reach the chickens, but in this country few chickens need be more than a week old before being allowed into a sunlit run, provided that some sort of protection, about 2 to 3 feet high, be placed round the run to keep off the cold winds which are occassionally encountered, especially on the high veld. The outside run should be as fresh as possible and should lie idle for at least eight months of the year. One reason why early hatched chickens do so much better than the late hatchings, is that the later birds are generally reared on ground already contaminated by the earlier broods.

If entirely new ground could be given, it would be found that August and September-hatched grow as well as those hatched in June and July. Many poultry breeders advocate early hatching, but this is a question that requires consideration. Early hatching is useful on occasions, especially if a trade be done in the sale of pedigree cockerels. Again it may be found advantageous to hatch some pullets early, in as much as, although these will come into lay in December and moult towards the end of March or the beginning of April, yet after the moult is over these pullets will make quite useful breeders if the owner be short of that class of stock. The pullet eggs laid in December, 1926, and January and February this year were worth from 8*d*. to 1*s*. per doz., and were sometimes difficult to sell at these prices, whereas in March, April and May, they increased from 1/6 to 3 per doz. The early hatched pullets were then moulting, and it would have paid much better to have had them hatched later so as to be in full lay when eggs were dearer.

For commercial purposes, I consider July and August the best hatching months for heavy breeds, while August and September are most suitable for the light breeds, the middle of July to the middle of August being ideal for the former and the middle of August to the middle of September for the latter. These dates are for the high velt, but the climate in South Africa varies so much that no definite dates would be suitable for the whole of the vast sub-continent.

The pullets should then come into lay during the latter half of February or the beginning of March, and will lay right through the season when eggs are dearest.

The main thing in chicken rearing is to keep the little things growing from start to finish, but do not force in any way. Precocious pullets laying at 4 to 4½ months old are a delight to the beginner, but the old hand prefers to get the first eggs from a flock of from 5½ to 6 months old in the case of light breeds, and from 6 to 7 months old for heavy breeds.

One point that should be made clear is that the baby chickens require as narrow a ration as a hen in full lay. Chickens about two months old often droop and gradually waste away until death takes place.

A Greenish Tinge.

If such chickens be examined carefully a greenish tinge may be apparent in the skin underneath the back portion of the wing and sometimes over most of the outer skin of the abdomen. This tinge emanate from the gall bladder. An examination will show the bladder greatly distended and full of greenish coloured liquid, which being greatly in excess of the requirements of the body, oozes through and gradually poisons the system. This excess of gall is caused through the insufficient supply of flesh forming food, or in other words, the feeding of too wide a ration, i.e., one deficient in protein, especially animal matter. In nature, the young of all birds are generally hatched in the spring months of the year when there is an abundant supply of insect life easily obtainable and this, along with young and tender plant life, forms the largest part of the food of the young birds for some very considerable time. Animal protein, therefore, would appear to be essential to the well-being of the young chickens and this can be supplied in the form of meat or fish-meal.

In nature, the supply of insect life gradually dies down as Autumn approaches and in its place comes an ample supply of seeds of all sorts. The supply of tender green food also diminishes. The result is that the young birds become pulp and lay on a supply of fat sufficient to carry them over

the winter months when food of all sorts is scarce. It is only when the store of fat has been used up that wild birds begin to think of mating up and laying their eggs for the rearing of the next generation.

The domestic fowl being differently fed and warmly housed, should not wait until the spring of the year before commencing to lay.

Natural Conditions Upset.

Natural conditions are entirely upset in a well managed poultry yard. These may, however, be found to a great extent on many farms where the fowls are left to take care of themselves, picking up such food as they can find and roosting in trees or in some other exposed place. Very few winter eggs will be collected from birds reared under such conditions.

Get Rid of the Cockerels.

After the chickens are six or eight weeks old, the cockerels of the light breeds can easily be distinguished and these should be separated from the pullets. Unless these be pedigree bred or egg production, or be the progeny of show specimens, the sooner they are got rid of the better. Young cockerels of the light breeds, weighing from a pound to a pound and a half, can generally, be sold at the rate of about sixpence a pound, live-weight, and it pays better to sell them at that size than to wait until they weigh from four to five pounds. To the man who has to buy everything, the extra weight will have been bought at a cost of food that will not leave any return for the trouble taken. Further, the disposal of surplus cockerels allows the extra space for the growing pullets and what a difference this makes to their welfare!

Separating the Sexes.

The question of determining the sexes is often, in some of the heavy breeds, a difficult one. For instance, in the case of Wyandottes it is sometimes almost impossible to tell the sex until the neck and the saddle hackles commence to grow. The wattles of the cockerels sometimes grow faster than those of the pullets, but this test is by no means infallible. Except in the matter of extra space for the pullets the renewal of the cockerels of the heavy breeds is not so essential as in the case of the light breeds, for they are not nearly so precocious and do not worry the pullets until they are at least four or five months old. Whether these heavy breed cockerels can be kept as a payable proposition is a point which each poultry farmer must decide for himself. If free range can be given it may pay handsomely to rear them to a weight of six or seven pounds and then especially fatten them off for a week or two before sending to market. This is a trade which must come, but first of all the consuming public needs much education before they realize that there must be a very considerable difference in price between a scraggy, illfed, often diseased, probably ancient fowl and a young, tender, and plump one.

Should Light Breed Cockerels be Dubbed?

Pedigree cockerels may be managed much the same as pullets, only the culling of weak birds must be very much stricter, and should be commenced as soon as defects begin to show. One culling is quite insufficient as it is only when the bones set, about the time that the adult plumage appears, that malformation in body structure become apparent. If one out of three cockerels passes the final test, I am usually quite satisfied. This balance will be well worth breeding from. One point which appears to be much debated

is whether light breed cockerels, intended solely for the breeding pen and not for the show bench, should be dubbed. I am of opinion, that for flock breeding, where six or eight cockerels are sometimes run together, it is best to dub them when they are three or four months old. There is less chance of fighting in a large flock than when there are only two or three cockerels placed with the hens, but there is still that chance and dubbed birds cannot damage each other to the same extent as those which are not dubbed. Further, I find, that birds dubbed at this age seem to develop more fully than those left in a natural state and to give better fertility when mated up.

The cockerels having been disposed of except those intended for breeding purposes, it is necessary to consider what is to be done with the growing pullets.

The Growing Pullets.

The pullets should be given as much room as is possible, plenty of house room and plenty of outside run. Overcrowding is the greatest curse and prevention of the successful rearing of all young birds. The runs used for rearing should have been lying idle for some very considerable time. So much am I convinced of this that in the plan I have drawn up for laying out my new poultry plant, I have set aside eight runs, each 50 feet by 120 feet, for rearing the pullets. These runs will be used only from the time the pullets are removed from the brooder-house until they are ready to be drafted either to the laying sheds or to single pens, that is, just before they commence to lay. This would be a matter of from three to, at the outside, four months and these runs will be idle during the remainder of the year.

Every poultry farmer has not sufficient ground to allow for this, but as far as possible the pullets should be removed from the brooder house at from six to eight weeks old, according to the state of the weather, and their new quarters should be as ample as possible in every way. If these runs have been planted with Kikuyu grass so much the better, as no green food will then need to be fed to the birds, unless a little occasionally for a change.

At this stage no forcing of any kind must be attempted. The birds should grow slowly, but surely, so that they build up a well-developed body before egg production commences. From four to six months old the meat or fish-meal, fed earlier, can be somewhat reduced; and the birds put gradually on to the full laying mash after they have been placed in the quarters which they are to remain in during the pullet laying year.

The Partial Moult.

Pullets hatched during the period recommended towards the beginning of this article, if placed in their laying quarters just before commencing to lay, should not drop into even a partial moult, but the earlier hatched birds are very liable to do so. There has been much discussion of late as to the cause of this. The general opinion is that owing to the warm days of summer and early autumn the sexual reproductive organs of these early hatched pullets are developed before their bodies are fully matured. The strain of producing eggs and growing at the same time is too much for the birds and the whole system is reduced in vigour. Condition is lost and a mould ensues. English and American breeders have recently advocated the feeding of maize in fairly large quantities to such pullets, even going so far as to recommend placing the maize in troughs so that the birds can continue to feed later than is possible if the grain is placed amongst the litter. In this way the condition of the birds is maintained and, although somewhat fewer

eggs are produced per week, the ultimate gain, if the moult can be staved off, is very considerable, as the eggs produced late are worth at least double of those produced in December and January.

Preventing Early Laying.

Moving the birds from one house to another when between four to four and a half months old, in the case of light breed pullets, is advocated as it tends to stop early laying somewhat. The heavy breeds may be moved at five to five and a half months. However, feeding a fairly wide ration at this time will have more effect. Once the pullets have been put into their permanent quarters, just before commencing to lay, they should not be moved again, otherwise a moult is almost sure to follow. This is no doubt one of the reasons why so large a percentage of the birds moult at the beginning of the laying tests, especially so in the case of light breeds. These are much more excitable than most of the heavy breeds.

Again, the tamer one can keep one's pullets the better layers they will be. This is probably a reason why trap-nested pullets often lay better than their untrapped sisters. The constant handling ultimately makes them so accustomed to the attendant that they become so tame and contented that they do not waste energy flying and rushing about at every slight sound. For the same reason strangers should not be allowed to actually enter the laying houses.

Growing Stage Mash.

The following is a mash used from the age of about four to five months, according to breed, and, during the time before the introduction of the laying mash when egg production is to be encouraged. Any other similar mixture can be used, according to what can be most easily obtained at a cheap rate. Forcing must not be allowed at this stage, especially in the case of earlier hatched pullets. In the case of those hatched later, the weather being cooler when they are at the developing stage, they can naturally be fed a somewhat narrower ration than their older sisters. Otherwise they might, and probably would, remain out of profit too long.

The mash advocated is: 400 lb. wheaten bran; 150 lb. fine pollard; 150 lb. Sussex oats; 100 lb. lucerne meal; 50 lb. meat and bone meal; 20 lb. fine bone flour; 3 lb. fine salt.

This is fed with crushed mealies only as a grain feed. If wheat can be obtained at a reasonable price it may be fed with advantage twice a week. Further if abundance of green food is procurable, the lucerne meal may be omitted from the mash.

Very many points have not been touched upon in this article. However, beginners may get some benefit from what I have written. The following are the mixtures used from babyhood to four months old, after which the chickens are treated as adults, with the addition in their mash of an extra percentage of bone flour for a month or two, and less meat or fish meal.

Chicken Mixtures.

No. 1.—Dry Mash: from 4 Days to 4 Weeks.

100 lb. wheaten bran, 25 lb. fine pollard, 25 lb. Sussex ground oats, 15. lb. lucerne meal (finely sifted), 10 lb. good meat and bone meal or fish meal, 5 lb. bone flour or fine bone meal, ½ lb. fine table salt.

No. 1.—Chicken Grain.

100 lb. finely crushed and screened yellow maize, 200 lb .kibbled wheat or good cockle wheat.

No. 2. Chicken Dry Mesh: from 4 Weeks to 4 Months.

300 lb. bran, 150 lb. pollard, 150 lb. Sussex ground oats, 100 lb. fine lucerne meal, 50 lb. good meat or fish meal, 20 lb. bone flour or fine bone meal, 2 lb. fine table salt.

No. 2. Chicken Grain.

200 lb. kibbled wheat or good cockle wheat, 200 lb. finely crushed and screened yellow maize, 100 lb. white Kaffir corn, 100 lb. fairly finely crushed peas.—*The South African Poultry Magazine,* Vol. XXIII., Nos. 185 and 189, 1927.

Live Stock in the Tropics.

A. L. BAKER, B.Sc., (Agric.)

IN the old established agricultural countries of the North, the keeping of livestock and production of marketable animal products play just as important a part in the general economy of agriculture, as does the growing of crops. Here the importance of maintaining the humus or organic matter in the soil has long been understood. Consequently, in nearly all types of farming, stocks and crops are judiciously blended. Crops are consumed by stock and the manure returned to the land to maintain its fertility. Furthermore, the fertility of the soil can be maintained without recourse to heavy applications of purchased manures, and products such as straw, which might otherwise be of little or no value, can be profitably fed to stock, while the distribution of labour throughout the year is usually more uniform and economical. The point to be emphasized, however, is that under old and well established conditions of agriculture, the importance of the inter-relationship of crops and stock cannot be over-rated where the policy is to crop the land continuously, and at the same time to keep it in good heart.

Turning to the tropics, an entirely different state of affairs presents itself. Here, generally speaking, crop products are far more important than livestock, and with the exception of perhaps India and Rhodesia, little or nothing has been done to develop a livestock industry. Stock do exist in all tropical countries, but up to the present their development has been almost entirely along lines suitable for the production of working animals, and little attempt has been made to produce animals more suitable for milk or meat or wool. In some of the earlier developed tropical countries, such as Trinidad, the effect of soil exploitation are already manifest. Growing the same crop year after year, without adequately compensating the soil for the organic matter and mineral constituents removed, has resulted in the exhaustion of much of the land, and in the incidence of disease due both to lack of vigour in plants and the absence of rotations. When it is remembered that the breakdown and the utilization of humus is extremely rapid in tropical soils, the problem becomes more acute Hence any increase in the number of livestock with the consequent production of more organic manure is bound to be a step in the right direction. Under such conditions, and especially where systems of "one-cropping" are practised, any diversification of agriculture must prove advantageous.

It is not the writer's opinion or idea that animal industries, similar to those of the temperate zones might be established in the tropics. It is doubtful whether this is desirable, even were it possible. In the first place, cattle or livestock as a whole are less suited to tropical than to colder climates, and moreover the demand for meat and other animal products is less in the tropics. This is due to several causes, one of which is that many native races, such as the Buddhist and Brahmin population of India are vegetarians, and others are only small eaters of meat. It is also recognized by medical science that people living in the tropics require less

meat than those of colder countries. The chief point at issue is not so much the establishment of new industries, but the improvement and where desirable, increase in numbers of the already existing domestic animals of the tropics, which at present somewhat inadequately supply the needs of the population. For example, by scientific feeding and management, it would doubtless be possible to double the milk yield of many of the scrub cows, which are so common throughout the equatorial zones, without any appreciable increase in cost.

To those familiar with northern livestock, it would seem at first sight that all that is required is to import quantities of the improved breeds of the North and build up improved herds from them. This has often been done on a large scale, but in more cases than not, with disastrous results. It must be realized that immediate and complete reformation of livestock in the tropics can never be attained. For various reasons, the process must necessarily be a slow one, but provided the initial steps are based on sound and businesslike lines, there is little reason why, given time, satisfactory and desirable results should not be obtained. In the first place, it has been found by experience that only certain of the northern breeds of stock are in any way adapted to withstand tropical conditions, and even with these, there are often many difficulties to be overcome before they can be successfully established. Cattle from the north often fail to thrive in the tropics, and rapidly deteriorate or die from disease to which they are usually far more susceptible than the naturally more resistant and acclimatised native breeds. As a consequence, the attempt to grade up native cattle by the use of northern stock, lacking in vigour under tropical conditions has often ended in complete failure. Experimental work on a small scale has first to be done, and then, only those classes of livestock which have been proved by experience to give satisfactory results should be used on any extensive scale. The precaution of inoculating all imported sires against redwater disease before shipment, and the introduction of animals at an early age, when their natural resistance is high, would allow them to become acclimatised before service and possibly to acquire natural immunity, and might do much to reduce the present somewhat high death rate amongst bulls. It must be emphasized that where male animals are imported with the object of grading up native stock, only superior sires having desirable characteristics and of known ancestry and prepotency should be used. And even with the native cattle themselves, much improvement may be obtained by the ordinary methods of selective breeding, and by the avoidance of haphazard and undesirable matings which are at present so common.

There is a wide field open for research in the tropics, both in the sphere of organized breeding, scientific feeding, management and sanitation. With regard to feeding, the amazing strides and almost incredible results which have been obtained in the last few years in the science and economics of this important subject, by such men as James Mackintosh at Reading, and Boutflour in Wiltshire, tend to show that work in the tropics is sadly behind-hand in this respect. One of the stumbling blocks to progress in the science of feeding outside temperate countries at present, is the fact that little or nothing is known about the digestibility of some of the locally grown foods. But here again, important work in this connection has been initiated in India, and when conclusive results are obtained, they should give a great stimulus to the practice of systematic rationing. From the point of view of the availability of foodstuffs, in the matter of concentrates, the tropics are well supplied. Besides an abundance of foods rich in starch, foods of high protein and oil content such as pulse grains, cotton

seeds and coconut residues, etc., are easily obtained locally. In the case of green forage, while much of the grazing land may be of poor quality, it can easily be supplemented by soiling crops, cut and fed green. Elephant grass, Para grass, Guatemela grass, sugar-cane tops, sweet potato wines, green pulses, etc., could be utilised for this purpose. Silage from these materials could be made to tide over the period of the year when green stuff is scarce or unobtainable.

While, in many countries, local departments of agriculture are doing much to improve generally livestock by the establishment of Government Farms, where good stud stock are kept and are available for use on the native cattle, the process of grading up must necessarily be slow, unless supported by strong legislation. Only male animals licensed by the Government, after examination by a competent veterinary surgeon, should be allowed to be used for service. These animals, should be declared free from disease, and of sufficient quality to improve rather than grade the native herds. This might mean the enforcement of compulsory castration, and from the human point of view, only qualified men, certified as such, should be allowed to perform this operation, as native unskilled methods may often prove both crude and cruel. Inspectors empowered to inspect native stock, and to enforce proper sanitation, feeding and management in cases of obvious neglect would be required, and certain diseases would have to be made notifiable to the police. Government subsidies on really good sires have gone far towards producing some of the more famous breeds in temperate countries, and this is a practice which might well be emulated to advantage in the improvement of stock in the tropics.—*Tropical Agriculture.* Vol. IV. No. 11, November, 1927.

Departmental Notes.

Progress Report of the Experiment Station, Peradeniya.

For the Months of November and December, 1927.

Tea.

After the 1925 pruning a number of bushes with more or less decayed stems were treated as follows:—

(1). 8 bushes—All decayed wood scraped out and cavities filled with a mixture of "Mexphalte" and Sawdust.

(2). 8 bushes—All decayed wood scraped out and cavities filled with a mixture of "Plascom" and liquid fuel.

(3). 8 bushes—All decayed wood scraped out, cavities drained, and a mixture of Skene's enamel wax and tar painted on to the exposed surfaces.

(1). The filling had lasted well but in every case decay had actively continued under the filling and no useful purpose had been achieved.

(2). The filling had mostly disintegrated and the decay had actively proceeded.

(3). Most of the bushes had died and very little evidence was forthcoming as to the value of this treatment. In one case where a cavity had not been properly drained and water had collected the wax had become soft and useless. Otherwise the mixture had lasted well and appeared to form a satisfactory water-proof covering.

The expense of cleaning out bushes and inserting such filling is very high and it would appear that unless a means can be found first to effectively kill the organism causing the rot without damage to the bush, even with the most satisfactory material, filling of cavities is of doubtful value. This conclusion does not apply to the application of Skene's wax.

Rubber.

Plot 174 ($3\frac{1}{8}$ acres) was planted with budded rubber in November.

The object is to test the influence of stock on scion. There are twenty five different combinations. Buds from five different mother trees have been budded on to their own stocks and stocks of four other mother trees. There are 400 plants. All plants were cut off 6 inches above the buds about three weeks before planting out. Five weeks after planting 30 plants had sprouted and in another 350 plants the bud was alive, 12 plants had died and were replaced, and in another 8 the buds had died. These will be budded again on the other side when the stocks have become well established. The failures therefore total 20, or 5% of the number planted.

Four trees of which latex records have been kept for a year from November 1st, 1926, to October 31st, 1927, by the method described in leaflet No. 43, were selected for pollarding for budwood. The minimum calculated yields of dry rubber per annum of these trees varied between 15 lb. and 18 lb; but the actual yields may have been considerably larger.

Cacao.

Four years' records of individual yields of pods from 133 trees in the "B" cacao revealed the fact that, with one exception, the trees bearing the largest numbers of pods all bore small pods.

A test was then made to ascertain the relative amounts of dry cacao obtained from equal number of large pods and small pods. Four lots of 150 large pods and 4 lots of 150 small pods were taken. The results were as follows:—

Large pods.

	Weight of 150 pods	Weight of dry cacao obtained.
Lot 1.....	235 lb.	16 lb.
,, 2.....	220 ,,	$14\frac{1}{2}$,,
,, 3.....	188 ,,	$13\frac{3}{4}$,,
,, 4.....	225 ,,	15 ,,
Average	217 ,,	$14\frac{3}{4}$,,

Small pods.

	Weight of 150 pods.	Weight of dry cacao obtained.
Lot 5.....	136 ,,	12 ,,
,, 6.....	124 ,,	10½ ,,
,, 7.....	126 ,,	11 ,,
,, 8.....	138 ,,	11¼ ,,
Average	131 ,,	11¼ ,,
'ercentage of eights from :rge pods	60 ,,	79 ,,

This indicates that although the larger pods had a greater proportion of shell, an equal number still gave 21% more dry cacao than was obtained from a similar number of small pods.

The method of recording yields in experiments by numbers of pods cannot therefore be considered satisfactory. In the manurial experiment now in progress wet weights of cacao from the different plots are recorded.

Green Manures and Cover Crops.

The results of 2 years' experience with *Indigofera endecaphylla* in tea have been incorporated in an article for the *Tropical Agriculturist.*

The first unfavourable report of the growth of this cover crop has been received from an estate at an elevation of 6250 feet. The Superintendent reports that in steep poor soil no cover had been formed after 18 months, and added that the elevation appeared too high for any useful growth.

In the last week of September alternate rows of seeds and cuttings of *Centrosema pubescens* were planted in plot 174 (new budded rubber plot).

Rather dry weather followed and none of the cuttings survived: the seeds all germinated well and a good cover is promised. Previous experience has also indicated that this plant is more easily propagated from seed.

Cattle.

Four Kangayam calves have been born. These are doing well.

Sweet Potatos.

Yield trials with a number of varieties have been carried on over a period of 6 years. Below are given the average of five yields in pounds per acre.

Pumpkin Yam	...	...	14623
Gandia	...	...	11128
Joe's	...	...	9072
Porto Rico	...	...	8480
Jaune	...	...	8015
Red Jersey	...	...	7998
Red Bourbon	...	...	6327
Sealy's	...	...	5713
Red Bermuda	...	...	4470

Stock plots of six of the best varieties are being maintained for supplying planting material.

General.

The proposed and very necessary increase of the labour force for which funds were allotted this financial year has not yet been possible owing to the non-completion of a set of lines which were included in the 1926-27 estimates.

T. H. HOLLAND,
Manager.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st DECEMBER, 1927.

Province, &c.	Disease	No of Cases up to date since Jan. 1st, 1927	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	1,053*	20	1021	9	22	1
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	5	...	...	5	...	...
	Rabies (Dogs)	5	...	...	...	...	5
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	231	12	213	5	11	2
	Anthrax	1	...	...	1	...	...
	Rabies (Dogs)	42	4	...	...	...	42
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	30	1	30	...	...	...
	Anthrax	12	...	...	12	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	762	52	755	...	7	...
	Anthrax	8	...	...		...	...
	Piroplasmosis	8	8	8	...	...	...
	Rabies (Dogs)	17	...	...	13	...	4
Southern	Rinderpest	32	...	8	23	...	1
	Foot-and-mouth disease	11	11	10	1	...	...
	Surra	2	...	...	2	...	...
	Black Quarter	5	...	...	5	...	...
	Haemorrhagic Septicaemia	6	...	2	4	...	...
Northern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	8	...	8	...	...	...
	Piroplasmosis	1	...	1	...	...	...
	Rabies (Dogs)	1	...	...	...	...	1
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	241	...	226	15	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	11	...	2	9	...	...
North-Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	766	96	664	6	96	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	1	...	1	...	...	...
	Rabies (Dogs)	3	...	...	1	...	2
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	342	...	328	14	...	...
	Anthrax	...	...	...	...	...	...
	Haemorrhagic Septicaemia	6	...	...	6	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	58	...	56	2	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	12	...	...	12	...	...
	Rabies (Dogs)	1	...		1	...	...
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	119	...	118	1	...	...
	Anthrax	...	...	...	...	...	...

* 1 case in a pig.

G. W. STURGESS,
Government Veterinary Surgeon.

Colombo, 10th January, 1927.

METEOROLOGICAL

DECEMBER, 1927.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction During Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	80·4	+1·2	76	5·1	NNE	118	3·63	6	— 1·75
Puttalam -	78·3	+0·7	82	4·2	NNE	119	3·98	11	— 2·31
Mannar -	80·4	+1·6	76	6·1	NNE	238	1·01	8	— 6·87
Jaffna -	78·0	+0·4	78	5·0	NE	89	30·4	11	— 7·42
Trincomalee	79·6	+1·0	81	6·0	NNE	198	8·32	16	— 5·84
Batticaloa -	78·1	+0·1	85	6·3	N	198	21·82	19	+ 5·25
Hambantota -	79·2	+0·6	81	4·9	NE	249	2·82	10	— 2·57
Galle -	79·2	+0·8	78	6·7	Var.	113	5·17	10	— 1·58
Ratnapura -	81·2	+1·8	78	6·0	—	—	5·66	14	— 3·38
Anu'pura -	76·9	—0·1	80	6·4	—	—	4·33	11	— 4·44
Kurunegala -	79·4	+1·2	74	6·3	—	—	1·96	7	— 5·39
Kandy -	75·8	+1·2	76	5·6	—	—	6·41	13	— 2·54
Badulla -	70·4	—0·3	88	7·0	—	—	8·43	19	— 3·84
Diyatalawa -	64·7	—0·3	88	8·0	—	—	4·97	19	— 3·93
Hakgala -	61·8	+3·6	86	6·8	—	—	15·85	27	+ 2·36
N'Eliya -	59·3	+1·3	76	7·2	—	—	4·94	15	— 3·83

The rainfall of December was markedly in deficit over nearly the whole island and particularly so in the nothern half.

Deficits of more than 5 inches occurred over about a quarter of the island including the whole of the Jaffna Peninsula.

The chief area in which average was reached was along the east coast from Batticaloa to Kalmunai inclusive. Others were at Urubokka and the district south west of it, near Bibile, and at Hakgala. St. Martin's (Rangala) was the only station to reach a total of thirty inches but was well below its own average for December, which is over forty. The highest offset above average was ten inches at Urubokka whose total was 23.2. Rainfalls of over 5 inches in a day were reported at several stations near the east coast from the 15th onwards. The heaviest rain was on the 27th when fifteen stations had over five inches and three of the Eastern Province stations reported over seven inches.

Wind velocities at the low-country stations were about average, though more above than below. High winds were however experienced at some of the up-country stations, notably on the 28th, when a gale was reported at Poonagalla while the anemometer at Haputale gap recorded over 40 miles per hour on each of the 26th, 27th and 28th.

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